SECTION 21 13 13 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Specialty valves.
5. Pressure gages.
6. Iron butterfly valves with indicators.
7. Check valves.
8. Iron OS&Y gate valves.
9. Trim and drain valves.
11. Exposed-type fire-department connections.

1.3 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

B. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.

C. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer, licensed in the State of Missouri, responsible for their preparation. Shop drawings and hydraulic calculations shall be submitted to MUHC for review and approval.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings

1. Drawings:

a. Provide coordination in determining adequate clearance and space requirements for fire protection equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.

b. Provide coordination drawings indicating structural components, reflected ceiling layout, fire protection items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment. Existing items that are expected to conflict with new work shall also be modeled in the coordination drawings. This applies to all disciplines.

c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.

d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the “change order” process.

e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves. Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid addi-
tional access panels. If additional access panels are required, they shall be pro-
vided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devic-
es, studs, fire/smoke ratings, and structural support requirements.

B. Design Data:

1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13,
that have been approved by authorities having jurisdiction, including hydraulic
calculations if applicable.

C. Welding certificates.

D. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as
described in NFPA 13. Include "Contractor's Material and Test Certificate for
Aboveground Piping."
2. Flow Test Data: Fire sprinkler contractor shall perform a new flow test on site as part of
this project to verify the flow test information.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in
emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective
covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with
space for minimum of six spare sprinklers plus sprinkler wrench. Include number of
sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with
sprinklers and wrench for each type of sprinkler used on Project.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installer’s responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

C. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and weld ends.

D. Use the following precautions during storage:

   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

E. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

F. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:


B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.

   1. Available fire-hydrant flow test records indicate the following conditions:

      b. Performed by: University of Missouri.
2. Sprinkler system design shall be approved by authorities having jurisdiction.

a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.

b. Sprinkler Occupancy Hazard Classifications:
   1) Building Service Areas: Ordinary Hazard, Group 1.
   2) Cylinder Storage and Hydrogen Room: Extra Hazard, Group 1.
   3) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   4) General Storage Areas: Ordinary Hazard, Group 1 for storage up to 10 feet, Ordinary Hazard, Group 2 for storage exceeding 10 feet.
   5) Laboratories: Class C or D laboratories, Ordinary Hazard, Group 1.
   6) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   7) Office and Public Areas: Light Hazard.
   8) Telecommunications Rooms: Ordinary Hazard, Group 1.

3. Minimum Density for Automatic-Sprinkler Piping Design:

a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.

b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.

c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.

4. Maximum Protection Area per Sprinkler: According to UL listing.

5. Total Combined Hose-Stream Demand Requirement:

a. Light Hazard: 100 gpm for 30 minutes.

b. Ordinary Hazard: 250 gpm for 60-90 minutes.

c. Extra Hazard: 500 gpm for 90-120 minutes.

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 40, Black-Steel Pipe: ASTM A 135/A 135M; ASTM A 795/A 795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Malleable- or Ductile-Iron Unions: UL 860.
D. **Cast-Iron Flanges:** ASME 16.1, Class 125.

E. **Steel Flanges and Flanged Fittings:** ASME B16.5, Class 150.

1. **Pipe-Flange Gasket Materials:** AWWA C110, rubber, flat face, 1/8 inch thick; ASME B16.21, nonmetallic and asbestos free; or EPDM rubber gasket.
   
   - Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
   - Class 150 and Class 300, Ductile-Iron or Steel, Raised-Face Flanges: Ring-type gaskets.

2. **Metal, Pipe-Flange Bolts and Nuts:** Carbon steel unless otherwise indicated.

F. **Steel Welding Fittings:** ASTM A 234/A 234M and ASME B16.9.

1. **Welding Filler Metals:** Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. **Grooved-Joint, Steel-Pipe Appurtenances:**

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   - Anvil International.
   - Corcoran Piping System Co.
   - National Fittings, Inc.
   - Shurjoint-Apollo Piping Products USA Inc.
   - Smith-Cooper International.
   - Tyco by Johnson Controls Company.

2. **Pressure Rating:** 175-psig minimum.

3. **Grooved-End Fittings for Steel Piping:** ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.

4. **Grooved-End-Pipe Couplings for Steel Piping:** AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 **SPECIALTY VALVES**

A. **Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."**

B. **Pressure Rating:**

1. **Standard-Pressure Piping Specialty Valves:** 175-psig minimum.
C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Automatic (Ball Drip) Drain Valves:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Reliable Automatic Sprinkler Co., Inc. (The).
   4. Type: Automatic draining, ball check.

2.4 SPRINKLER PIPING SPECIALTIES

A. Flow Detection and Test Assemblies:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AGF Manufacturing, Inc.
      b. Reliable Automatic Sprinkler Co., Inc. (The).
      c. Tyco by Johnson Controls Company.
   4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
   5. Size: Same as connected piping.
   6. Inlet and Outlet: Threaded or grooved.

B. Sprinkler Inspector’s Test Fittings:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AGF Manufacturing, Inc.
b. Triple R Specialty.

c. Tyco by Johnson Controls Company.

d. Victaulic Company.


4. Body Material: Cast- or ductile-iron housing with sight glass.

5. Size: Same as connected piping.

6. Inlet and Outlet: Threaded.

2.5 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

2. Reliable Automatic Sprinkler Co., Inc. (The).
3. Tyco by Johnson Controls Company.
4. Victaulic Company.
5. Viking Group, Inc.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

E. Sprinkler Finishes: Chrome plated, bronze, and painted.

F. Special Coatings: Wax lead and corrosion-resistant paint.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Concealed type, with flat cover plate except for Extra Hazard spaces. For Extra Hazard, chrome-plated steel, one piece.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat semi-recessed.

H. Sprinkler Guards:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   b. Reliable Automatic Sprinkler Co., Inc. (The).
   c. Tyco by Johnson Controls Company.
   d. Victaulic Company.
   e. Viking Group, Inc.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.6 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. ADT Security Services, Inc.
   b. McDonnell & Miller.
   c. Potter Electric Signal Company, LLC.
   d. System Sensor.
   e. Viking Corporation.

4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
7. Design Installation: Horizontal or vertical.

C. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell International company.
b. Kennedy Valve Company; a division of McWane, Inc.
c. Potter Electric Signal Company, LLC.

3. Type: Electrically supervised.
5. Design: Signals that controlled valve is in other than fully open position.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. AGF Manufacturing, Inc.
2. AMETEK, Inc.
3. Ashcroft Inc.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0- to 250-psig minimum.

E. Label: Include "WATER" label on dial face.

2.8 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" and shall bear UL mark, or:

B. FM Global Approved: Valves shall be listed in its "Approval Guide."

C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

D. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
F. NFPA Compliance: Comply with NFPA 13 for valves.

G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

H. Valve Sizes: Same as upstream piping unless otherwise indicated.

I. Valve Actuator Types:
   1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
   2. Handwheel: For other than quarter-turn trim and drain valves.
   3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

J. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Ames Fire & Waterworks; A WATTS Brand.
   3. FEBCO; A WATTS Brand.
   5. Fivalco Inc.
   7. Kennedy Valve Company; a division of McWane, Inc.
   8. Mueller Co.
   9. NIBCO INC.
   10. Reliable Automatic Sprinkler Co., Inc. (The).
   11. Shurjoint-Apollo Piping Products USA Inc.
   12. Tyco by Johnson Controls Company.
   13. United Brass Works, Inc.
   15. Viking Corporation.
   16. WATTS.
   17. Wilson & Cousins Inc.

2.9 IRON BUTTERFLY VALVES WITH INDICATORS

A. Description:
   1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
   3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
   4. Seat Material: EPDM.
   5. Stem: Stainless steel.
   6. Disc: Ductile iron, and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.

2.10 CHECK VALVES

A. Description:

3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.

2.11 IRON OS&Y GATE VALVES

A. Description:

3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.

2.12 TRIM AND DRAIN VALVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Hammond Valve.
4. Kennedy Valve Company; a division of McWane, Inc.
5. Mueller Co.
6. NIBCO INC.
7. Victaulic Company.
8. WATTS.

B. Ball Valves:

1. Description:
   a. Pressure Rating: 175 psig minimum.
   b. Body Design: Two piece.
   c. Body Material: Forged brass or bronze.
   d. Port size: Full or standard.
   e. Seats: PTFE.
   f. Stem: Bronze or stainless steel.
   g. Ball: Chrome-plated brass.
   h. Actuator: Handlever.
   i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
   j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

C. Globe Valves:

1. Description:
   a. Pressure Rating: 175 psig minimum.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc Holder and Nut: Bronze.
   f. Disc Seat: Nitrile.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

2.13 BACKFLOW PREVENTERS

A. Double-Check, Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers
   offering products that may be incorporated into the Work include, but are not limited to
   the following:
   a. Ames Fire & Waterworks; A WATTS Brand.
   b. Apollo Flow Controls; Conbraco Industries, Inc.
   c. FEBCO; A WATTS Brand.
   d. Flomatic Corporation.
   e. Mueller Co.
   f. WATTS.
2.14 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. American Fire Hose & Cabinet.
5. GMR International Equipment Corporation.
7. Venus Fire Protection Ltd.
8. Wilson & Cousins Inc.

B. Standard: UL 405.

C. Type: Exposed, projecting, for wall mounting.

D. Pressure Rating: 175 psig minimum.

E. Body Material: Corrosion-resistant metal.

F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

G. Caps: Brass, locking type, with gasket and chain.

H. Escutcheon Plate: Round, brass, wall type.

I. Outlet: Back, with pipe threads.

J. Number of Inlets: Single 4\" Storz inlet with 30 degree downturn.

K. Escutcheon Plate Marking: Similar to "AUTO SPKR."

L. Finish: Rough brass or bronze.
3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

C. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

D. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

E. Examine threads on valve and mating pipe for form and cleanliness.

F. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

G. Do not attempt to repair defective valves; replace with new valves.

H. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

I. Examine roughing-in for sprinkler system to verify actual locations of piping connections before fire-department connection installation.

J. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SERVICE-ENTRANCE PIPING

A. Install backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes NPS 2 and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

I. Install alarm devices in piping systems.

J. Install hangers and supports for sprinkler system piping according to NFPA 13.

K. Install pressure gages on riser or feed main, and at each sprinkler test connection. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.

L. Provide a means for air venting at the high point of each system in accordance with NFPA 13.

M. Fill sprinkler system piping with water.

N. Install sleeves for piping penetrations of concrete or block walls, ceilings, and floors. Comply with requirements for sleeves specified in NFPA 13.

O. Install sleeve seals for piping penetrations of exterior concrete walls and slabs on grade. Comply with requirements for sleeve seals specified in NFPA 13.

P. Install escutcheons for exposed piping penetrations of walls, ceilings, and floors in finished spaces. Comply with requirements for escutcheons specified in NFPA 13.
3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system’s pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
   1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

3.6 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

3.7 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type fire-department connections.

B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

3.8 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

3.9 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   4. Energize circuits to electrical equipment and devices.
   5. Coordinate with fire-alarm tests. Operate as required.
   6. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.11 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain valves and equipment.

3.13 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:
   1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.

3.14 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers except for Extra Hazard spaces. For Extra Hazard, semi-recessed sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
3. Upright Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 13 13
SECTION 22 05 00 - BASIC PLUMBING REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

A. This section describes Basic Plumbing Requirements required to provide for a complete installation of all mechanical systems for this project. This section shall apply to all other Division 22 specification sections as well as all work shown on the drawings.

B. It is the intent of the Plumbing Division of the Specifications that all plumbing work specified herein be coordinated as required with the work of all other Divisions of the Specifications and Drawings so that all installations operate as designed.

C. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation to the satisfaction of the Owner’s representative.

D. The Contractor shall note that, in some cases, piping as shown on the Drawings provide general location and routing information only. The Contractor shall be responsible for providing interference-free systems with proper clearance to facilities and equipment.

E. Where the word “provide” is used, it shall mean “furnish and install” unless otherwise noted or specified.

F. Note that the words “mechanical” and “plumbing” are used interchangeably throughout the Division 22 and 23 specification sections.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section and all other sections of Division 22.

1.3 DESCRIPTION OF WORK

A. The work included under this section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete mechanical systems required by these specifications and/or shown on the drawings of the contract.
B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, piping fixtures, etc. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

1.4 PERMITS

A. All permits, fees, licenses, etc. required for this project shall be obtained by the Contractor.

1.5 QUALITY ASSURANCE

A. Installers shall have at least 5 years of successful installation experience on projects with mechanical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation, unless noted otherwise in other mechanical sections.

B. Manufacturer of equipment and materials must be regularly engaged in the manufacture of the specified equipment and material with similar construction and capacities and whose products have been in satisfactory use in similar service for not less than five (5) years, unless noted otherwise in other Mechanical Sections.

C. Qualify welding processes and operators for structural steel according to AWS D1.1. "Structural Welding Code - Steel.

D. Quality welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

E. Comply with provisions of ASME B31 Series "Code for Pressure Piping", including all addenda.

F. Contractor signed welder certificate(s) shall be submitted. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current. A record shall be maintained on the job site showing the date and results of qualification tests for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to the Owner's representative.

G. For all the refrigerant work/service required by this project, all refrigerant technicians shall be EPA/ASHRAE 34 certified for corresponding classification type I, II, III and/or IV.

1.6 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following as applicable:
1. Safety and Health Regulations for Construction.
2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
4. ACCA - Air Conditioning Contractors of America.
5. ACGIH - American Conference of Governmental Industrial Hygienists.
6. ADC - Air Diffusion Council.
8. AIHA - American Industrial Hygiene Association.
14. ASME - The American Society of Mechanical Engineers.
17. CABO – Council of American Building Officials.
18. CAGI - Compressed Air and Gas Institute.
19. CTI - Cooling Tower Institute.
21. ETL - Engineering Tests Laboratory.
23. HI - Hydraulic Institute.
24. HYD I - Hydronics Institute.
25. IAPMO – International Association of Plumbing and Mechanical Officials.
26. ICBO - International Conference of Building Officials.
29. NEC - National Electrical Code.
30. NEMA - National Electrical Manufacturers Association.
32. NSF - National Sanitation Foundation.
33. SAE - Society of Automatic Engineers.
34. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association.
35. TEMA - Tubular Exchanger Manufacturers Association.
36. UL - Underwriters Laboratories, Inc.
38. International Mechanical Code.
39. Other governing, state, and local codes that apply.

1.7 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections “General Conditions” and “Special Conditions”.

BASIC PLUMBING REQUIREMENTS

The Clark Group
September 2019
Columbia, Missouri

Contract Documents

MU Project #: CP190421
TCEP Project #: 624-157-18
B. The Architect/Engineer’s review of submittals, including any corrections or comments made on the shop drawings during the review process, do not relieve Contractor from compliance with requirements of the Contract Documents. The review is only a review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for confirming and correlating all quantities and dimensions; selecting fabrication process and techniques of construction; coordinating his work with that of all other trades; and performing his work in a safe and satisfactory manner. The Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Architect/Engineer's review of those drawings.

C. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Architect/Engineer. All such portions of the work shall be in accordance with reviewed submittals and the associated manufacturer recommendations.

D. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Plumbing Sections.

1. Certified performance and data with system operating conditions indicated. All coil, fan, and pump performance data shall be computer generated.
2. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
3. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loading, required clearances, and methods of assembly of components.
4. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electrical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of electrical equipment and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
5. Maintenance Data: Submit maintenance data and parts list for each mechanical equipment, control and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

E. Coordination drawings

1. Drawings:
   a. Provide coordination in determining adequate clearance and space requirements for fire protection equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.
b. Provide coordination drawings indicating structural components, reflected ceiling layout, fire protection items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment. **Existing items that are expected to conflict with new work shall also be modeled in the coordination drawings. This applies to all disciplines.**

c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.

d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the “change order” process.

e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves. Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.

2. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination drawing process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:

a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.

b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.

3. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).

a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.

b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):
1) Roof drain leaders  
2) Large waste piping  
3) Sprinkler mains  
4) Equipment located above the ceiling  
5) Heating hot water piping  
6) Chilled water piping  
7) Conduit runs 2 inches and larger  
8) Cable tray  
9) Bus duct  
10) Recessed light fixtures  
11) Building wiring or cable trays  
12) Ceiling heights as shown in contract documents and thickness of system  
13) Soffits (including framing of supports)  
14) Access points and clearances required  
15) Access panels  
16) Valves  
17) Dampers  
18) Coils  
19) Ductwork  
20) Fire-rated wall, partition, and floor penetrations  
21) Steam and condensate piping  
22) Space allotted for future utilities  
23) Equipment in mechanical and electrical spaces

c. Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.

4. The coordination drawings shall be submitted to the Architect/Engineer and Owner’s representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Architect/Engineer, recommended solutions will be provided with the coordination drawings for review by the Architect/Engineer. The Architect/Engineer will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.

5. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Architect/Engineer and the Owner for review on a monthly basis with changes “clouded” and brought to the attention of the Architect/Engineer and the Owner.

6. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Architect/Engineer revisions necessary to the work of others not directly affected by the change order.
7. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

F. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

1.8 SUBSTITUTES

A. Refer to the General Conditions and Special Conditions sections of this Specification for general substitution requirements and information.

1.9 WARRANTY

A. Refer to the General Conditions section of this Specification for general warranty requirements and information. Additional warranty requirements are specified in subsequent Plumbing Sections.

1.10 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Operate each system and item of equipment in a test run of appropriate duration, but no less than 7 days, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Any system placed in temporary operation for testing or for the convenience of the Contractor during construction shall be properly maintained and operated by the Contractor.

C. All systems shall be protected against freezing, flooding, corrosion or other forms of damage prior to acceptance by the Owner.

D. Material or equipment damaged, shown to be defective or not in accordance with the Specifications shall be repaired or replaced to the satisfaction of the Owner’s representative.

E. All tests shall be made after notification to and in the presence of the Owner’s representative.

F. Before starting up any system, each piece of equipment comprising any part of the system shall be checked for proper lubrication and any other condition which may cause damage to the equipment or endanger personnel.

G. After systems have been demonstrated to be satisfactory for 7 consecutive days and ready for permanent operation, all permanent pipe line strainers shall be cleaned, valve and packings properly adjusted, lubrication checked and replenished if required. Temporary piping, etc. shall be removed and openings restored in a permanent manner acceptable to the Owner’s representative.
H. Conduct a walk-through instruction seminar for the Owner's personnel pertaining to the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, maintenance requirements, operational diagrams, temperature control provisions, sequencing requirements, security, safety, efficiency and similar features of the systems. Walk through must be documented as to those attending and subjects covered. Walk through document(s) shall be signed and dated by the contractor's representative and the owner's representative.

1. Provide instruction seminar, minimum 4 hours each, for each of the following items: Water Purification System.

I. At the time of substantial project completion, turn over the prime responsibility for operation of the plumbing equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

1. If any systems are operated prior to substantial completion, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

1.11 AS-BUILT DOCUMENTS

A. Prepare as-built documents in accordance with the requirements in Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in above, indicate the following installed conditions:

1. The Plumbing Contractor shall provide the Owner with as-built drawings for ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units and indicate all devices requiring periodic maintenance or repair, such as control power transformers, LACS panels/routers, field controllers, duct static pressure sensors, piping pressure sensors, etc.
2. All plumbing systems as described in the Specifications and/or shown on the drawings.
3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 22 Section "Plumbing Identification." Indicate actual inverts and horizontal locations of underground piping.
4. Equipment/material locations (exposed and concealed), dimensioned from prominent building lines.

1.12 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

2. PRODUCTS (NOT APPLICABLE).

3. EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Store and handle material and equipment in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Use proper lifting equipment where size/weight requires handling by such means.

D. Comply with manufacturer's rigging and moving instructions for unloading material and equipment, and moving them to final location.

E. Equipment requiring disassembly for access purposes shall be disassembled and reassembled as required for movement into the final location following manufacturer's written instructions.

F. Deliver material and equipment as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

G. Contractor shall schedule deliveries so as to minimize space and time requirements for storage of materials and equipment on site.

3.2 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

3.3 COORDINATION
A. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Coordinate the plumbing work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.
2. Within the limits indicated on the drawings, the maximum practicable space for operation, maintenance repair, removal and testing of mechanical and other equipment will be provided.
3. Pipes, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, ducts, and similar items shall be located so that they will not interfere with the intended use of other equipment.

C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

D. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

3.4 PLUMBING INSTALLATIONS

A. All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

B. The location of all equipment and systems shall be coordinated to preclude interferences with other construction.

C. Should interferences occur which will necessitate deviations from layout or dimensions shown on the Drawings, the Architect/Engineer and the Owner's representative shall be notified and any changes approved before proceeding with the work.

D. Arrange for chases, slots, and openings in other building components during progress of construction to allow for mechanical installations.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
G. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

H. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

I. Install plumbing equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Welding, sweating, or brazing operations

1. All cutting, welding, brazing, or sweating operations carried on in the vicinity of, or accessible to, combustible material shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.

2. When it is necessary to do cutting, welding, brazing, or sweating close to wood construction, in pipe shafts, or other locations where combustible materials can not be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. Position another individual nearby to guard against sparks and fire.

3. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations, or spatter from electric arc operations, a guard shall be kept at the place of work for at least one hour after completion to verify that smoldering fires have not been started.

4. Whenever welding or cutting operations are carried on in a vertical shaft or where floor openings exist, a fire guard shall be employed to examine all floors below the point of the welding or cutting operation. The fire guard shall be kept on duty for at least one hour after completion to verify that smoldering fires have not been started.

5. Before any work involving cutting, welding, brazing, or sweating operations is started, consult with the Architect/Engineer as to particular safety precautions to be employed on the work.

6. Obtain proper hot work permits as required.

3.5 ACCESSIBILITY

A. All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind.

3.6 LUBRICATION AND TOOLS
A. Provide a fresh charge of lubricant in accordance with manufacturer’s recommendations to all equipment requiring lubrication prior to start-up and maintain lubrication as required until acceptance by Owner.

B. Provide for each piece of equipment any special tools and a list of such tools required for the operation or adjustment of the equipment and turn over to the Owner’s representative prior to final acceptance of the equipment.

3.7 PIPING SYSTEMS PRESSURE TESTING

A. The following personnel in the order listed shall be considered acceptable witnesses of all piping pressure testing:

1. Owner’s Representative
2. Mechanical Engineer / Architect
3. General Contractor’s Foreman

B. Removal of pressure charge and associated drain down shall also be witnessed.

C. Mechanical contractor shall provide a minimum of 24-hour notice to at least one of the above listed parties before commencing any piping systems pressure test.

D. Pressure gauge requirements: Provide recently calibrated gauge with 4” face and a range such that test pressure is between 50% and 100% of gauge range. For example, a gauge with a 15 psig range is acceptable for a 10 psig pressure test, whereas a gauge with a 30 psig range is unacceptable in this application. Gauge resolution shall be suitable for type of testing, system size and test media. Gauge shall have been recently calibrated. Test duration shall be 1 hour.

E. All piping pressurizing equipment (i.e., air compressor) shall be disconnected before test is commenced and shall remain disconnected for the entire duration of the test.

F. Entire system shall be properly vented before test is commenced.

G. For specific piping pressure testing requirements and procedures, see applicable piping systems specification sections.

H. Submit completed “Pipe Pressure Test Log” provided at the end of this Section for each pressure test before final project closeout. Test log shall also be included in operation and maintenance manuals.

NOTE: USE MULTIPLE FORMS IF NECESSARY

3.8 EXTENT OF WORK
A. Access Panels

1. Furnish and install panels for access to valves and dampers and similar items where no other means of access, such as readily removable, sectional ceiling is shown or specified.

B. Cutting and Patching

1. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
   2. Contractor shall coordinate all cutting and patching of holes, in existing building and new construction which are required for the passage of mechanical work.
   3. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
   4. Cut, channel, chase and core drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
   5. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
   6. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
   7. Repair cut surfaces to match adjacent surfaces.
   8. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
      a. Uncover work to provide for installation of ill-timed work.
      b. Remove and replace defective work.
      c. Remove and replace work not conforming to requirements of the Contract Documents.
      d. Remove samples of installed Work as specified for testing.
      e. Install equipment and materials in existing structures.
      f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Excavation and Backfilling

1. Contractor shall perform all excavation and backfilling necessary to install the required mechanical work. Coordinate the work with other excavating and backfilling work in the same area.
2. Except as indicated otherwise, comply with the applicable sections in Division 2 of these specifications, excavation filling and backfilling (for structures) to 5’ outside the building line.
3. Trenching: Trench width shall be no more than required for shoring, bracing and performance of the work. All necessary shoring and bracing shall be installed to insure worker safety, proper installation of mechanical work, and protection of adjacent structures. Provide all dewatering as required. Depth shall not exceed that required to achieve the specified depth of cover and overdig will be permitted for bedding material only. All trenches shall be open cut from the surface.
4. **Bedding**: All work shall be properly bedded whether on virgin soil or on granular bedding as specified. All granular bedding shall be laid on undisturbed soil. PVC and copper piping shall have a 4" crushed stone bed conforming to specification for granular material in Division 2. If rock is encountered, excavate to a point 4" below installed bottom elevation of piping and provide bedding as called for above.

5. **Haunching**: Haunching shall be brought up on both sides of the pipe for a distance of 1/3 the pipe diameter and shall be of the same material used for bedding.

6. **Backfill**: Backfilling shall not begin until installation has been tested for leaks.

7. **Placement**: Place all granular material in lifts of 12" maximum compacted to 100% of maximum dry density as determined as ASTM D698. Place soil in 6" lifts compacted to 95% of maximum density as determined by ASTM D698. Do not place any backfill until excavations have been cleaned of all water, debris and loose or soft soil.

8. **Protection**: At least 72 hours prior to excavating, for each phase, Contractor shall contact the Owner's Representative to arrange for utility locates in the construction area.

9. **Contractor** shall provide temporary supports for all underground utilities crossing an excavation.

10. **Provide** all required barricades, fencing, signs, lights, etc. as necessary for the protection of the workers and of the general public.

11. **Excess Material**: All excess earth and other material resulting from the excavation shall be removed from site daily by the Contractor.

12. **Landscape work, pavement, flooring and similar exposed finish work** that is disturbed or damaged by excavation shall be repaired and restored to their original condition by the Contractor.

**D. Painting**

1. Contractor is to field paint plumbing equipment and materials in specified areas as noted on the plumbing plans, plumbing schedules and in the specifications.

2. In concealed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted with one coat of zinc rich paint.

3. In exposed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted in accordance with Section 099100.

**E. The responsibility of work specified under Division 22 and 26 is clarified under, Section 220513, "Electrical Requirements for Plumbing Equipment. Contractor is to coordinate all electrical requirements prior to ordering powered plumbing equipment.**

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ADDITIONAL

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PRESSURE GAGE INFORMATION

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NOTE: USE MULTIPLE FORMS IF NECESSARY
SECTION 22 05 13 - ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

1. GENERAL

1.1 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.
   1. Electrical components and materials shall be UL labeled and listed.

B. References.
   1. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:
      b. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
      c. NEMA Standard 250 – Enclosures for Electrical Equipment.
      d. NEMA Standard KS 1 – Enclosed Switches.

C. Submittals.
   1. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, or as required by the individual equipment specification sections.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and holding

G. Related sections.
   1. Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.2 SUMMARY
A. This section specifies the basic requirements for electrical components which are an integral part of packaged plumbing equipment. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged plumbing equipment. In addition, this section covers necessary coordination issues between plumbing and electrical disciplines. All plumbing and electrical construction documents must be completely reviewed by the Plumbing and Electrical Contractors prior to the submission of bids. Any discrepancies in the documents should be brought to the Architect/Engineer’s attention at that time. Failure to properly coordinate or review documents in advance of submission of bids will not be valid cause for changes to the overall Contract amount.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for plumbing equipment are scheduled on the Drawings.

2. PRODUCTS

2.1 SAFETY SWITCHES

A. See specification section 26 05 01 – Basic Electrical Materials and Methods.

3. EXECUTION

3.1 CONTRACTOR COORDINATION

A. General contractor is responsible for coordination of all subcontractors and associated scopes of work.

END OF SECTION 22 05 13
SECTION 22 05 19 – PLUMBING METERS AND GAUGES

1. GENERAL

1.1 SECTION INCLUDES

A. Pressure gauges and pressure gauge taps.

B. Thermometers and thermometer wells.

C. Piping pressure and temperature test plugs.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Accurately record actual locations of instrumentation.

F. Delivery, storage, and handling

2. PRODUCTS

2.1 PRESSURE GAUGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection, liquid-filled.

B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.
F. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.2 PRESSURE GAUGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.3 THERMOMETERS, GENERAL

A. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

B. Scale range: Temperature ranges for services listed as follows:

1. Hot Water: 30 to 240 deg with 2-degree scale divisions (0 to 115 deg C with 1-degree scale divisions).
2. Cold and Tepid Water: 0 to 100 deg F with 2-degree scale divisions (minus 18 to 38 deg C with 1-degree scale divisions).

2.4 GLASS THERMOMETERS

A. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

B. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

C. Tube: Red reading, magnifying lens, with non-mercury fluid.

D. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

E. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

2.5 THERMOMETER WELLS

A. Thermometer Wells: Brass or stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.
2.6 PIPING PRESSURE AND TEMPERATURE TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:


3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer’s instructions.

3.2 THERMOMETERS

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install as shown on plans and elsewhere as indicated.

C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

3.3 PRESSURE GAUGES

A. Install pressure gauges in piping tee with pressure gauge valve, located on pipe at most readable position.

B. Install as shown on plans, and elsewhere as indicated.

C. Pressure Gauge Ball Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.4 TEST PLUGS

A. Test Plugs: Install where indicated, located on pipe at most readable position. Secure cap.

3.5 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION 22 05 19
SECTION 22 05 29 – PLUMBING HANGERS AND SUPPORTS

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and equipment hangers, supports, anchors, saddles and shields.

B. Sleeves and seals.

C. Mechanical sleeve seals.

D. Flashing and sealing equipment and pipe stacks.

E. Sealants, firestop insulation, putty and compounds.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References

B. Submittals

C. Delivery, storage and handling

2. PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Plumbing Piping:

1. Conform to International Plumbing Code, International Fuel Gas Code, ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89 as applicable.

B. Pure Water Piping and Laboratory Waste and Vent Piping:

1. Conform to manufacturer’s recommendations as applicable.

C. Hangers and Supports:

1. Hangers for Hot and Cold Pipe Sizes 1/2 to 1-1/2 Inch, Carbon steel, adjustable swivel, band type.

2. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
7. Wall Support for Hot Pipe Sizes 6 Inches (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 22 07 19.
16. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
17. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
18. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
19. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
20. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
21. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
22. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
23. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
24. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
25. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
26. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
27. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
28. See Section 22 05 48 for vibration isolation hangers and supports.

2.2 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
2.3 INSERTS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Internally Threaded Screw Anchors: Internally threaded, self tapping screw anchors, Power Fasteners Snake or approved equivalent.
   1. Tested in accordance with ACI 355.2 and ICC-ES AC193 for use in structural concrete under the design provisions of ACI318 (Strength Design method using Appendix D)

2.4 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Metal Counterflashing: 22 gage galvanized steel.

C. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.

D. Floor Drain and Floor Sink Flashing: 40 mil thick chlorinated polyethylene (CPE), equivalent to Choraloy.

E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 SLEEVES

A. Sleeves for Pipes Through Rated Floors and Walls: Schedule 40 steel pipe.

B. Sleeves for Pipes Through Non-Rated Floors: Schedule 40 steep pipe, extended 2” above floor.

C. Sleeves for Pipes Through Non-Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel, extended 2” above floor. See drawings for further detail.

2.6 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

A. Refer to Section 07 84 13 for firestopping materials and methods. Refer to drawings for additional details.

B. Sealants:
   1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
   2. Fire/smoke rated partitions: Silicone based caulking, UL listed.
C. All fire-rated sealants and firestops shall be installed by a certified firestop contractor. Reference front-end specifications for further information.

2.7 MECHANICAL SEALS

A. Mechanical Seals: Modular mechanical type, consisting of interlocking low durometer EPDM synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with type 316 stainless steel bolts and reinforced plastic polymer pressure plates which cause rubber sealing elements to expand when tightened, providing a watertight and gas-tight seal and electrical insulation. Provide Advance Products & Systems Model Innerlynx, Link-Seal LS-316, or approved equivalent.

1. A sleeve shall be provided for each mechanical seal.
   a. Thermoplastic sleeves: Sleeve shall have smooth walls and shall be made of molded non-metallic high density polyethylene (HDPE) with an integral solid water stop, Advance Products & Systems Model PWS, Century-line Model CS, or approved equivalent.
   b. Steel sleeves: Sleeve shall have smooth walls, shall be made of Schedule 40 steel with an integral welded solid water stop, and shall have corrosion-resistant coating, Advance Products & Systems Model GWS, Century-line Model WS, or equivalent.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS
PLUMBING HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Support fire protection systems piping independently from other piping systems. Fire main piping may be trapezed with other piping systems. Coordinate trapeze hangers with the Sprinkler Contractor.

C. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

D. Place hangers within 12 inches of each horizontal elbow.

E. Use hangers with 1-1/2 inch minimum vertical adjustment.

F. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

I. Support riser piping independently of connected horizontal piping.

J. Provide copper plated hangers and supports for non-insulated copper pipe.

K. Design hangers for pipe movement without disengagement of supported pipe.

L. Prime coat steel hangers and supports in the mechanical room and other exposed areas. Refer to the Architectural reflected ceiling plans for location of exposed ceilings. Hangers and supports located in attic space, crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

M. Adjust hangers to distribute loads equally on attachments and to achieve specified pipe slopes.

N. Space hangers for pure water and laboratory waste and vent systems to avoid pipe sags. Use manufacturer-recommended V-groove channel if necessary to maintain sag-free installation.

O. Saddles, Shields and Inserts

1. Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

2. Install protective shields MSS Type 40 on cold piping that has vapor barrier. Shields shall span an arc of 180 degrees (360 degrees on trapeze hangers with U-bolt clamps) and shall have dimensions in inches not less than the following:
3. Pipes 8 inches and larger shall have wood inserts.
4. Insert materials shall be at least as long as the protective shield.
5. Provide manufacturer-recommended saddles, inserts, and/or shields where cellular foam insulation is used. The removal of sections of cellular foam insulation for the purpose of pipe support is not acceptable.

3.4 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.5 FLASHING

A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls and floors.

B. Flash floor drains in floors with topping over finished areas with CPE membrane, a minimum of 12 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.

C. Seal floor, shower, mop sink, etc. drains watertight to adjacent materials.

D. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

E. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.
3.6 SLEEVES

A. Provide pipe and duct sleeves at all fire/smoke rated partitions, exterior wall penetrations and wall penetrations into exposed areas. Pipe and duct sleeves are not required for penetrations through non-rated concealed partitions.

B. At the Contractor’s option, pipe sleeves may be omitted if the wall or floor is core drilled, except in areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.).

C. Set sleeves in position in formwork. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Sleeves through floors shall be grinded flush with finish floor level. In areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.), sleeve shall extend a minimum of 2” above finish floor.

F. Where piping penetrates non-rated ceilings or walls, close off space between pipe or duct and adjacent work with urethane rod stock and caulk air tight.

G. Seal pipe penetrations through non-rated floors.

1. Where piping is not located in a rated shaft and it penetrates a single non-rated floor, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.
2. Where piping is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between pipe and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.

H. Where piping penetrates rated floor, ceiling, or wall, close off space between pipe or duct with appropriate fire rated sealant, insulation, putty or compound. Refer to the Drawings for fire/smoke rated wall locations and the appropriate ratings.

I. Install chrome plated steel escutcheons on piping at finished surfaces.

J. Waste, vent and storm pipe penetrations through the concrete floor slab shall be encased in the poured concrete slab.

K. PVC pipe casing around the cold and hot water and gas piping shall be encased in poured concrete when penetrating the floor slab. Seal the opening between the piping and PVC casing with putty or rigid polyisocyanurate insulation plug and seal with caulking.

L. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.
3.7 HANGER SCHEDULES


B. Reference manufacturer's recommendations for pure water piping and laboratory waste and vent piping.

END OF SECTION 22 05 29
SECTION 22 05 53 – PLUMBING IDENTIFICATION

1. GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe Markers.

D. Ceiling Tacks/Stickers.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Commissioning requirements.

1. See section 01 91 13 – General Commissioning Requirements for all commissioning requirements.

B. References

C. Related Sections

D. Submittals

E. Quality Assurance

1.3 PROJECT RECORD DOCUMENTS

A. Record actual locations of tagged valves.

2. PRODUCTS

2.1 NAMEPLATES

A. Equipment Mark Nameplates: Laminated three-layer plastic with engraved black letters (matching equipment mark indicated on drawings) on light contrasting background color, with minimum 3/4 inch high letters.
B. Equipment Nameplates: Factory-applied permanent nameplate indicating the manufacturer’s name, model, serial number, temperature and pressure design, and any other data necessary to conform with specified requirements. On equipment installed outdoors, nameplate shall be stamped steel or engrave plastic.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.

B. Chart: Typewritten list that is plastic laminated and mounted in mechanical room. Valve list is to coordinate with mechanical piping schematics if provided on plans.

C. Pipe Schematics: Valve numbers are to be labeled on Engineer schematic drawings, plastic laminated and schematic shall be mounted in mechanical room.

2.3 PIPE MARKERS


B. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings; minimum information indicating flow direction arrow and identification of fluid being conveyed.

2.4 CEILING TACKS/STICKERS

A. Description: ½” self adhesive color coded stickers.

B. Color code as follows:

1. Yellow - HVAC equipment
2. Red - Fire dampers/smoke dampers, sprinkler/standpipe system valves
3. Green - Plumbing valves
4. Blue - Heating/cooling valves

3. EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION
A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic tape pipe and duct markers in accordance with manufacturer's instructions. Directional arrow tape shall be overlapped to ensure proper adhesion and no peeling of tape in future.

D. Identify air handling units, exhaust fans, chillers, pumps, heat generating, heat rejecting, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

E. Identify pressure reducing valves, backflow preventers, valves, and meters with tags.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify valves in main and branch piping with tags.

H. Tag automatic controls, instruments, and relays. Key to control schematic.

I. Identify piping, concealed or exposed, with plastic tape pipe markers. For pipes ¾” and smaller, identify piping with tags. Identify service, flow direction, and pressure when applicable, i.e. low pressure steam, high pressure steam. Install in clear view from floor and align with axis of piping. Locate identification not to exceed 15 feet on straight runs including risers and drops, more often in congested areas, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Provide a minimum one label per pipe per room. Where pipes are racked, install pipe markers on each pipe in the same location to aid in differentiating each pipe in the rack.

J. Provide ceiling stickers or machine generated labels to locate valves, dampers, or HVAC equipment above T-bar type panel ceilings. Locate ceiling sticker on the ceiling grid closest to equipment. Label each sticker with the device located above the ceiling, i.e. VBR-33.

END OF SECTION 22 05 53
SECTION 22 07 16 – PLUMBING EQUIPMENT INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Equipment insulation.

B. Covering.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Quality assurance.


D. Delivery, storage and handling.

E. Environmental requirements.

   1. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
   2. Maintain temperature during and after installation for minimum period of 24 hours.

2. PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible.

   1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.
   2. Maximum service temperature: 250 degrees F.
   3. Maximum moisture absorption: 0.2 percent by volume.
   4. Density: 2.0 lb/cu ft.

B. Vapor Barrier Jacket

   1. ASTM C921, kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.

D. Vapor Barrier Lap Adhesive: compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

F. Manufacturers: Subject to compliance with requirements, provide one of the following:
   1. Owens Corning
   2. Johns Manville
   3. Knauf Insulation
   4. Or equivalent.

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible.
   1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.
   2. Maximum service temperature: 450 degrees F.
   3. Maximum moisture absorption: 0.1 percent by volume.
   4. Density: 3.0 lb/cu ft.

B. Vapor Barrier Jacket
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.02 perm.
   3. Secure with self sealing longitudinal laps and butt strips.
   4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Vapor Barrier Lap Adhesive: Compatible with insulation.

D. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

E. Manufacturers: Subject to compliance with requirements, provide one of the following:
   1. Owens Corning
   2. Johns Manville
   3. Knauf Insulation
   4. Or equivalent.

2.3 CELLULAR FOAM
A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. 'K' ('ksi') value: ASTM C177 or C518; 0.27 at 75 degrees F.
2. Minimum service temperature: -40 degrees F.
3. Maximum service temperature: 220 degrees F.
4. Maximum moisture absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
5. Moisture vapor transmission: ASTM E96; 0.20 perm inches.
7. Maximum smoke developed: ASTM E84; 50.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.4 CANVAS JACKET

A. Fabric: ASTM C921, 6 oz/sq yd, plain weave cotton treated with dilute fire retardant lagging adhesive.

B. Lagging Adhesive: Compatible with insulation.

3. EXECUTION

3.1 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Do not insulate factory insulated equipment.

C. On exposed equipment, locate insulation and cover seams in least visible locations.

D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

F. Insulated dual temperature equipment or cold equipment containing fluids below ambient temperature:
1. Provide vapor barrier jackets, factory applied or field applied.
2. Finish with glass cloth and vapor barrier adhesive.
3. Insulate entire system.

G. For insulated equipment containing fluids above ambient temperature:

H. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
   1. Finish with glass cloth and adhesive.
   2. For hot equipment containing fluids do not insulate flanges and unions, but bevel and seal ends of insulation.

I. Inserts and Shields:
   1. Application: equipment 1-1/2 inches diameter or larger.
   2. Shields: galvanized steel between hangers and inserts.
   3. Insert location: between support shield and equipment and under the finish jacket.
   4. Insert configuration: minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

J. Finish insulation at supports, protrusions, and interruptions.

K. For equipment in mechanical equipment rooms or in finished spaces, finish with canvas jacket sized for finish covering.

L. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

M. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

3.3 TOLERANCE

A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.4 FLEXIBLE GLASS FIBER INSULATION SCHEDULE

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<th>Equipment</th>
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3.5 CELLULAR FOAM INSULATION SCHEDULE

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<td>1-1/2&quot;</td>
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</tbody>
</table>
Cold flanged strainer bodies. 1-1/2"
Cold system tanks/vessels 1-1/2"
Condensate drain pans 1-1/2"

END OF SECTION 22 07 16
SECTION 22 07 19 – PLUMBING PIPING INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References

B. Submittals

C. Delivery, Storage and Handling

1.3 QUALITY ASSURANCE

A. See Section 22 05 00.

B. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84, NFPA 255, and UL 723.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

2. PRODUCTS

2.1 GLASS FIBER

A. Insulation: ASTM C547; rigid molded, noncombustible.

1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.
2. Minimum Service Temperature: -20 degrees F.
3. Maximum Service Temperature: 300 degrees F
4. Maximum Moisture Absorption: 0.2 percent by volume.
B. Vapor Barrier Jacket

1. ASTM C921, White kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.

D. Vapor Barrier Lap Adhesive: compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

F. Fibrous Glass Fabric: Cloth, untreated; 9 oz/sq yd weight with 1.0 lb/cu ft density blanket.

G. Indoor Vapor Barrier Finish: Vinyl emulsion type acrylic, compatible with insulation, white color.

2.2 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. 'K' ('ksi') Value: ASTM C177 or C518; 0.27 at 75 degrees F.
2. Minimum Service Temperature: -40 degrees F.
3. Maximum Service Temperature: 220 degrees F.
4. Maximum Moisture Absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
5. Moisture Vapor Transmission: ASTM E96; 0.20 perm inches.
7. Maximum Smoke Developed: ASTM E84; 50.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.3 JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Plastic: High-impact-resistant; UV-resistant PVC complying with ASTM D 1784, Class 16354-C; One piece molded type fitting covers and sheet material, white color.

1. Minimum Service Temperature: -40 degrees F.
2. Maximum Service Temperature: 150 degrees F.
3. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
5. Maximum Smoke Developed: ASTM E84; 50.
7. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

C. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Thickness: 0.040 inch.
   2. Finish: Smooth.
   4. Fittings: Factory-fabricated fitting covers of same material, finish, and thickness as jacket.
      a. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

3. EXECUTION

3.1 EXAMINATION
A. Verify that piping has been tested before applying insulation materials.
B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION
A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
B. For elastomeric insulation systems, use inserts by the same manufacturer of the insulating system being installed (i.e. for Armaflex, use Amafix.)
C. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.
D. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
E. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
F. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
G. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

I. Where piping passes through fire walls indicated on the contract drawings, contractor shall install firestopping per firestop manufacturers instructions.

J. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

K. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

L. Repair damaged sections of existing mechanical insulation, damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

M. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

N. Wood blocking shall not be used.

O. On exposed piping, locate insulation and cover seams in least visible locations.

P. Inserts and Shields:

1. Refer to Section 22 05 29 for additional information.
2. Application: Piping 1 inch diameter or larger.
3. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
4. Insert Location: Between support shield and piping and under the finish jacket.
5. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
6. Insert Material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
7. Provide inserts and/or shields per manufacturer recommendations for cellular foam insulation applications in order to maintain continuous insulation throughout the pipe system. The removal of sections of cellular foam insulation to accommodate pipe supports is not acceptable. Manufacturer products specifically designed for supporting insulation and maintaining the integrity of the insulation system at pipe hanger locations, such Armaflex Armafix Insulation Pipe Hangers, are acceptable.

Q. Finish insulation at supports, protrusions, and interruptions.
R. For pipe exposed in finished areas, finish with white PVC jacket and PVC fitting covers.

S. For piping exposed in mechanical rooms below 8 feet above finished floor, finish with aluminum jacket and aluminum fitting covers.

T. All valves in insulated systems shall have valve stem extensions. Insulation installer shall notify the contractor and Owner if valves without stem extensions are encountered. All valves without stem extensions in areas where stem extensions are required shall be replaced.

3.3 TOLERANCE

A. Substituted insulation materials, where allowed, shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.4 GLASS FIBER INSULATION SCHEDULE

A. Plumbing Systems

<table>
<thead>
<tr>
<th>PIPING SYSTEM</th>
<th>PIPE SIZE:</th>
<th>THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water and Hot Water Recirc Systems</td>
<td>1-1/4&quot; &amp; smaller</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Hot Water and Hot Water Recirc Systems</td>
<td>1-1/2&quot; &amp; larger</td>
<td>1-1/2&quot;</td>
</tr>
</tbody>
</table>

3.5 CELLULAR FOAM INSULATION SCHEDULE

A. Plumbing Systems

<table>
<thead>
<tr>
<th>PIPING SYSTEM</th>
<th>PIPE SIZE:</th>
<th>THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Water Systems</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Tempered Water Systems</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Tepid Water to Emergency Fixtures</td>
<td>All sizes</td>
<td>None</td>
</tr>
<tr>
<td>Cold (&lt;65º F) Condensate Drain Piping</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Drain Piping Serving OA Plenum</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Branch Drain Piping Serving Floor Sinks</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Roof Drain Bodies</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Roof Drainage Systems Above Grade</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Plumbing Vents Within 20’ of Exterior</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Fire Sprinkler System Main Drain and Inspector’s Test Valve Drain Within 20’ of Building Exterior</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.1. DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process which are being directed by the CxA.

B. The systems to be commissioned are listed in Section 01 91 00 Part 1.11.

C. Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2. RESPONSIBILITIES

A. Plumbing Contractors. The commissioning responsibilities applicable to the plumbing contractor are as follows (all references apply to commissioned equipment only):

  Construction and Acceptance Phases

  1. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.

  2. Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment.

  3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.

     a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner/using agency-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner/Using Agency to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.

     b. The Commissioning Authority may request further documentation necessary for the commissioning process.

     c. This data request may be made prior to normal submittals.

  4. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

  5. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

  6. Provide assistance to the CxA in preparation of the specific functional performance test procedures specified. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

  7. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup. Refer to Section 01 91 00 Part 3.4 for further details on start-up plan preparation.

  8. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CxA for all commissioned equipment.
9. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

10. Address current A/E punch list items before functional testing.

11. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

12. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, CM and A/E and retest the equipment.

13. Prepare O&M manuals according to the Contract Documents.

14. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

15. Provide training of the Owner/Using Agency’s operating staff using expert qualified personnel as specified.

16. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Electrical Designer/Engineer

1. Refer to Section 01 91 00 or the responsibilities of the Plumbing Designer/Engineer.

1.3. RELATED WORK

A. Refer to Section 01 91 00 Part 1.8 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 Part 1.11 for systems to be commissioned and Section 01 91 00 Part 3.6 for functional testing requirements.

PART 2 - PRODUCTS

2.1. TEST EQUIPMENT

A. Division 22 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 Part 2.1 for additional Division 22 requirements.

PART 3 - EXECUTION

3.1. SUBMITTALS

A. Division 22 shall provide submittal documentation relative to commissioning equipment and systems as required in this Section Part 1, Section 01 33 00 Construction Submittal Procedures and Section 01 91 00 Part 3.3.

3.2. STARTUP

A. The plumbing contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 00 Part 3.4. Division 22 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning Authority or Owner/Using Agency.
B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CxA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3. FUNCTIONAL PERFORMANCE TESTS
   A. Refer to Section 01 91 00 Part 1.11 for a list of systems to be commissioned and to Part 3.6 for a description of the process.

3.4. TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS
   A. Refer to Section 01 91 00 Part 3.4 for specific details on non-conformance issues relating to prefunctional checklists and tests.
   B. Refer to Section 01 91 00 Part 3.7 for issues relating to functional performance tests.

3.5. OPERATIONS AND MAINTENANCE (O&M) MANUALS
   A. The following O&M Manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.
   B. Division 22 shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver to the GC for inclusion in the O&M manuals, according to this Section, prior to the training of Owner/Using Agency personnel.
   C. The CxA shall receive a copy of the O&M manuals for review.

3.6. TRAINING OF OWNER/USING AGENCY PERSONNEL
   A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 Part 3.9 for additional details.
   B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner/Using Agency personnel for commissioned equipment. Refer to Section 01 91 00 Part 3.9 for additional details.
   C. Plumbing Contractor. The plumbing contractor shall have the following training responsibilities:
      1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00 Part 3.9.
      2. Provide designated Agency personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
      3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
      4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
      5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
      6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
      7. Training shall include:
SECTION 22 08 00 - COMMISSIONING OF PLUMBING SYSTEMS

a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.

b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

c. Discuss relevant health and safety issues and concerns.

d. Discuss warranties and guarantees.

e. Cover common troubleshooting problems and solutions.

f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.

g. Discuss any peculiarities of equipment installation or operation.

h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1.1-2007 is recommended.

i. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut down and any emergency procedures and maintenance of all pieces of equipment.

9. The Plumbing Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

11. Duration of Training. The Plumbing contractor shall provide training on each piece of equipment listed in the following schedule. This list is not meant to be all inclusive but is to provide a representative example of the level of training required by the plumbing contractor. Plumbing contractor shall assign hours to each type of equipment/system and submit completed comprehensive list and schedule to CxA and Owner/Using Agency for review prior to implementation.

<table>
<thead>
<tr>
<th>Hours</th>
<th>System</th>
<th>Hours</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Heating Systems – Heat Exchangers, Pumps, Temper Valves, Storage Tanks, Controls</td>
<td></td>
<td>Reverse Osmosis System with Pump</td>
</tr>
<tr>
<td></td>
<td>Water Softener</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.7. DEFERRED TESTING

A. Refer to Section 01 91 00 Part 3.10 for requirements of deferred testing.

3.8. WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 Part 3.11 and the filled-out start-up, initial checkout and prefunctional checklists.

END OF SECTION 22 08 00
SECTION 22 10 00 - PLUMBING PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and pipe fittings.

B. Valves.

C. Sanitary waste and vent piping system.

D. Domestic water piping system

E. Laboratory water piping system

F. Storm water piping system.

G. Specialty gas piping system.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Valves: Manufacturer’s name and pressure rating marked on valve body.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Record actual locations of valves.

F. Delivery, storage, and handling

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code.
1.4 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.5 EXTRA MATERIALS

A. Provide two repacking kits for each size valve.

2. PRODUCTS

2.1 SANITARY WASTE AND VENT PIPING, BURIED WITHIN 5 FEET OF BUILDING


1. Fittings: Cast iron, ASTM A74, service weight.
2. Joints: ASTM C564 neoprene gasket system equivalent to Tyler Pipe Ty-Seal.

2.2 SANITARY WASTE AND VENT PIPING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A888 and CISPI 301, hubless, service weight for piping.

1. Fittings: Cast iron, ASTM A888 and CISPI 301, service weight.
2. Joints: Neoprene gaskets and heavy-duty stainless steel 4-band or 6-band clamp-and-shield assemblies.

2.3 WASTE P-TRAP PIPING AT LAB SINKS AND CUP SINKS AND FUME HOOD SINKS, ABOVE GRADE

A. Flame Retardant Polypropylene (PP) Pipe: ASTM F1412, Schedule 40 extruded pipe and molded drainage-pattern fittings meeting ASTM D1785, manufactured from PP resin complying with ASTM D4101, with mechanical joint ends. Resin shall include a flame retardant additive meeting ASTM D635.

1. Fittings: Drainage-pattern molded fittings of same type as pipe material. Fittings shall be designed for mechanical joining utilizing manufacturer’s recommended methods. Fittings shall have internal construction with chemical resistance equal to or better than the pipe and fittings.
2. Joints: Non-fused mechanical joining method as recommended by manufacturer.
3. Supports: All pipe supports shall use the pipe manufacturer’s recommended support system. Support spacing and materials shall be in accordance with the manufacturer’s written instructions and recommendations.
4. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. Fuseal II by George Fischer Sloane.
   b. Enfield by IPEX.
2.4 DOMESTIC AND LABORATORY WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B88, Type L, hard drawn.
   2. Joints: ASTM B32, solder, Grade 95TA, for piping 1-1/2" and smaller. AWS A5.8, BCuP-5 (15% silver bearing material) silver braze, for piping 2" and larger.

2.5 STORM WATER PIPING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A888 and CISPI 301, hubless, service weight for piping.
   1. Fittings: Cast iron, ASTM A888 and CISPI 301, service weight.
   2. Joints: Neoprene gaskets and heavy duty stainless steel 4-band or 6-band clamp-and-shield assemblies.

2.6 FLANGES, UNIONS, AND COUPLINGS

A. Pipe Size 2 Inches and Under:
   1. Ferrous pipe: 150 psig malleable iron threaded unions.
   2. Copper tube and pipe: 150 psig bronze unions with soldered joints.

B. Pipe Size Over 2 Inches:
   1. Ferrous pipe: 150 psig forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.
   2. Copper tube and pipe: 150 psig slip-on bronze flanges; 1/16 inch thick preformed neoprene gaskets.

2.7 DIELECTRIC CONNECTIONS:

A. Dielectric Nipples: Where connecting ferrous and non-ferrous piping materials, use dielectric nipples conforming to the following specifications to separate piping materials:
   2. Electroplated steel nipple complying with ASTM F 1545.
   3. Pressure Rating and Temperature: 300 psig at 225 deg F.
   5. Lining: Inert and noncorrosive, propylene.

2.8 SWING CHECK VALVES
A. Up to and including 2 inches: Bronze swing disc, 125 psig working pressure.

B. Over 2 inches: Cast iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

2.9 BALL VALVES

A. Up to and including 4 inches: Bronze two piece body, chrome plated steel full-port ball, teflon seats and stuffing box ring, lever handle.

2.10 BUTTERFLY VALVES

A. 3 inches and larger:

1. Standard: MSS SP-67, Type I.
2. Body Design: Lug type suitable for bidirectional dead-end service rated at 200 psig without use of downstream flange.
4. Seat: EPDM
5. Stem: One or two piece stainless steel.
6. Disc: Neoprene coated ductile iron or aluminum bronze.

2.11 STRainers

A. Size 2 inch and under: Screwed bronze body for 250 psig working pressure, Y pattern with 20-mesh stainless steel perforated screen.

B. Size 2-1/2 inch and larger: Flanged cast iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.12 CALIBRATED BALANCE VALVES

A. Pre-Set Balance Feature. Valves to be designed to allow Installing Contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with scheduled flow rates.

B. Valve Design and Construction. All valves shall have a calibrated orifice or venturi section, two ¼” threaded pressure tap ports with integral seals, and memory stop to retain the set position. Valves should be rated for 125 psig working pressure and 250 Deg. F maximum operating temperature.

C. Valves shall be selected based on flowrate, not on pipe size dimensions.

D. Preformed Insulation. All valves to be provided with molded insulation to permit access for balance and read-out.
2.13 DRAIN VALVES

A. Equipped with hose adaptor fitting and cap.

3. EXECUTION

3.1 EXAMINATION

A. Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Vent pipes shall extend minimum 12” above finish roof line or as required by code.

H. Provide clearance for installation of insulation and access to valves and fittings.

I. Provide access where valves and fittings are not exposed.

J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

K. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.
L. Install bell and spigot pipe with bell end upstream.

M. Install valves with stems upright or horizontal, not inverted.

N. Extend chains on valves with chainwheel operators down to maximum 5-feet above finished floor.

O. Install strainers in horizontal pipe or in vertical pipe such that flow is downward. Do not install strainers in vertical pipe with flow upward.

P. Install copper tubing under building slab according to CDA's "Copper Tube Handbook." Install ball valve directly upstream of each floor slab penetration.

Q. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105.

R. Install ball valve at all laboratory water connections to fume hoods and other laboratory equipment.

S. Install natural gas shutoff valves at each required piece of equipment. Provide gas regulators as necessary to accommodate equipment pressure requirements. Coordinate with equipment vendor.

T. For PP and PVDF piping, installation shall only be performed by factory trained and certified installers in accordance with the manufacturer's written procedures. Each installer shall complete the manufacturer's certification course, including written test examinations and submittal of test fusion welds to the factory for evaluation and file. Installation practices, including support spacing and expansion considerations, shall be in accordance with the manufacturer's certification course and written recommendations.

1. The manufacturer shall also provide training and certification for Owner's personnel at a time separate from the contractor training. Coordinate exact time with Owner.

2. Upon completion of the project, the contractor shall send electrofusion controller/heater back to factory for calibration and necessary repairs prior to delivering to the Owner. Contractor shall be responsible for any expense accrued due to the recertification and repair of the electrofusion controller/heater. Contractor shall also provide all associated components required to maintain the piping system.

U. Provide dewatering as necessary to accommodate the electrofusion joint-making process for all underground laboratory waste piping.

3.4 APPLICATION

A. Install unions downstream of valves and at equipment or apparatus connections.

B. Install valves for shut-off and to isolate equipment, part of systems, and vertical risers.

C. Install ball valves for throttling, bypass, or manual flow control services.
D. Provide flow control valves in water recirculating systems where indicated. Balance flow to maintain hot water at all plumbing fixtures.

E. Support storm piping at roof drains independent of drain.

3.5 ERECTION TOLERANCES

A. Establish invert elevations, slopes for drainage to 1/8 inch per foot minimum or as indicated on drawings. Maintain gradients.

B. Slope water piping and arrange to drain at low points.

3.6 PLUMBING PIPING PRESSURE TESTING

A. Test for leaks and defects all new plumbing piping systems and parts of existing systems, which have been altered, extended or repaired. Submit copy of Pipe Pressure Test Log provided in section 22 05 00 for each section of piping tested. Refer to International Plumbing Code for general pipe pressure testing requirements (i.e., test pressure gauges, inspections, etc.).

B. Leave uncovered and unconcealed all new, altered, extended, or replaced piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.

C. Repair all leaks and defects using new materials and retest all plumbing systems until satisfactory results are obtained.

D. Laboratory Waste and Vent Piping Systems.

   1. Test in accordance with manufacturer recommendations. Note that the use of air or other compressed gases will not be allowed for pressure testing of plastic laboratory waste and vent piping.

3.7 DISINFECTION OF WATER PIPING SYSTEMS

1. After water systems have been pressure tested and flushed, each system (including distribution system to building) shall be cleaned and disinfected per AWWA C651. Note that procedures shall require two (2) consecutive sets of acceptable samples taken at least 24 hours apart.

2. Take samples no sooner than 24 hours after flushing, from outlets and from water entry per AWWA 651, and analyze in accordance with AWWA C651.

3. Samples shall be subject to bacteriological testing by a recognized 3rd party testing agency. Send test reports to Owner for review. If unsatisfactory bacteriological results are found, the system shall be disinfected and retested again until satisfactory results are obtained.

3.8 SERVICE CONNECTIONS
A. Before commencing work check invert elevations required for connection to existing mains and branch piping, confirm inverts and ensure that these can be properly connected with slope for drainage.

END OF SECTION 22 10 00
SECTION 22 11 19 - PLUMBING SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

A. Backflow preventers.

B. Automatic flow balance valves.

C. Installation requirements of other plumbing specialties scheduled in Plumbing Fixture Schedule.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Project record documents

1. Record actual locations of plumbing specialties.

D. Operation and maintenance data.

E. Qualifications

F. Delivery, storage and handling.

2. PRODUCTS

2.1 BACKFLOW PREVENTERS

A. Reduced-Pressure-Zone Assembly Backflow Preventers

1. The assembly shall consist of an internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs. Seats and seat discs shall be replaceable in both check modules and the relief valve. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. Lead Free* reduced pressure zone assembly shall comply with state codes and standards, where applicable, requiring reduced lead content. The assembly shall also include two resilient seated isolation valves, four resilient seated test cocks and an air gap drain fitting.
assembly shall meet the requirements of: USC; ASSE Std. 1013; AWWA Std. C511; CSA B64.4.

2. Operation: Continuous-pressure applications.

3. End Connections:

   a. Threaded for NPS 2 and smaller;
   b. Flanged for NPS 2-1/2 and larger.

4. Accessories:

   a. Up to 2”:
      1) Quarter-turn ball valves: full port, resilient seated, lead free cast copper silicon alloy body;
      2) Strainer;
      3) Air-gap fitting.

   b. 2-1/2” to 3”:
      1) Non-rising stem resilient (NRS) gate valves.

5. Materials:

   b. 2-1/2” to 3”:
      1) Epoxy coated cast iron unibody with plastic seats;
      2) Relief valve with stainless steel seat and trim;
      3) Lead-Free cast copper silicon alloy body ball valve test cocks.

6. Pressure / Temperature:

   a. Up to 2”: Suitable for supply pressure up to 175 psi. Water temperature: 33 deg F to 180 deg F.
   b. 2-1/2” to 3”: Suitable for supply pressure up to 175 psi and water temperature at 110 deg F continuous, 140 deg F intermittent.

2.2 AUTOMATIC FLOW BALANCE VALVES

A. Externally adjustable balance valve with removable differential pressure cartridge and external locking handle. Flow cartridge must be removable from valve without removing the valve from
piping. Valve equipped with two capped ¼” readout valves. NPT end connections. Brass body with stainless steel spring, HNBR diaphragm and EPDM o-rings. MWP of 300 psig, temperature range of 14 to 250 degrees F., +/- 5% accuracy. Valves shall be identified with flow rate, pressure operating range, and coil designation.

B. Manufacturer: Bell and Gossett Ultraset or equivalent.

2.3 OTHER SPECIALTIES

A. Refer to Plumbing Specialties Schedule for required product information.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Pipe relief from backflow preventers to nearest drain.

C. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to either building exterior or floor drain (coordinate with plans). Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

D. Provide final certification for all testable backflow preventers, after installation, by certified cross connection device tester. Submit copy of successful test to owner representative.

END OF SECTION 22 11 19
SECTION 22 21 23 – PLUMBING PUMPS

1. GENERAL

1.1 SECTION INCLUDES

A. In-line circulators.

B. Deionized water distribution pump.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References.

B. Performance requirements.

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within ± 10 percent of scheduled performance and published operating curve.

C. Submittals.

D. Operation and maintenance data.

E. Qualifications.

F. Delivery, storage and handling.

G. Extra materials.

1. Provide one set of mechanical seals and gaskets for each pump.

2. PRODUCTS

2.1 IN-LINE CIRCULATORS

A. See pump schedule on drawings for performance requirements.

B. The pumps shall be of the horizontal system lubricated type specifically designed and guaranteed for quiet operation.
C. Pumps to be suitable for 140 deg F operation at 150 psig working pressure.

D. The pumps shall have a ceramic shaft supported by carbon bearings. Bearings are to be lubricated by the circulating fluid.

E. Pump body shall be lead-free bronze.

F. Motor stator to be isolated from circulating fluid through use of stainless steel can. Rotor to be sheathed in stainless steel.

G. Motors shall be non-overloading at any point on the pump curve. Motors shall have built-in thermal protection.

H. Subject to compliance with requirements, provide product by one of the following:

   1. Bell & Gossett
   2. Armstrong Pumps Inc.
   3. Grundfos Pumps Corp.
   4. Or equivalent.

2.2 DEIONIZED WATER DISTRIBUTION PUMP

A. See pump schedule on drawings for performance requirements.

3. EXECUTION

3.1 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.2 IN-LINE CIRCULATORS INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Provide line sized shut-off valve on pump suction and line sized soft seat check valve, shut-off valve, and balancing valve on pump discharge.

3.3 START-UP AND COMMISSIONING
A. Start-up pump in accordance to manufacturer written instructions.

B. Before and after start-up, perform the following preventative maintenance operations and checks:

1. Lubricate bearings.
2. After pump is started, check for proper rotation, proper mechanical operation and motor load to ensure that pump is not overloaded. Close pump balancing valve as required to bring pump motor load within motor nameplate data.
3. Check pumps to ensure it is not air bound or cavitating.

C. Coordinate pump testing, adjusting and balancing with Balancing Contractor. Complete additional preliminary work required by Balancing Contractor.

END OF SECTION 22 21 23
SECTION 22 40 00 - PLUMBING FIXTURES

1. GENERAL

1.1 SECTION INCLUDES

A. Downspout nozzles.
B. Cleanouts.
C. Water hammer arresters.
D. Floor drains, floor sinks and trench drains.
E. Hose bibs and wall hydrants.
F. Combination electric water coolers / bottle filling stations.
G. Installation requirements of plumbing fixtures scheduled in Plumbing Fixture Schedule.
H. Plumbing fixture carriers.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Commissioning requirements.
   1. See section 01 91 13 – General Commissioning Requirements for all commissioning requirements.
B. References
C. Submittals
D. Quality Assurance
E. Delivery, Storage and Handling

1.3 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and instructed by the manufacturer.
B. Confirm that millwork is constructed with adequate provision for the installation of countertop lavatories and sinks.

2. PRODUCTS

2.1 DOWNSPOUT NOZZLES

A. Refer to Plumbing Fixture Schedule for required product information.

2.2 CLEANOUTS

A. Exterior Surfaced Areas: Round or Square cast nickel bronze access frame and non-skid cover.

B. Interior Finished Floor Areas: cast iron body and frame, medium duty nickel bronze top to accommodate the following floor finishes as required:

1. Exposed rim type with recess to receive terrazzo or resilient floor finish.
2. Exposed finish type with standard mill finish.
3. Exposed flush type with standard scored or abrasive finish.
4. Concealed undercarpet flush type with mill finish and carpet marker.

C. Interior Finished Wall Areas: Line type with cast iron body and round gasket cover and round stainless steel access cover secured with machine screw.

D. Interior Unfinished Accessible Areas: Caulked or threaded type.

2.3 WATER HAMMER ARRESTERS

A. Standard: ASSE 1010 or PDI-WH 201.

B. Type: Diaphragm type.

C. Size: Size per manufacturer recommendations.

2.4 FLOOR DRAINS, FLOOR SINKS, AND TRENCH DRAINS

A. Refer to Plumbing Fixture Schedule for required product information.

B. Minimum floor drain size shall be 3” diameter.

2.5 HOSE BIBBS AND WALL HYDRANTS

A. Refer to Plumbing Fixture Schedule for required product information.
2.6 OTHER PLUMBING FIXTURES

A. Refer to Plumbing Fixture Schedule for all required product information.

2.7 PLUMBING FIXTURE CARRIERS

A. All wall mounted fixtures such as urinals, water closets, lavatories, drinking fountains, electric water coolers, etc. shall be installed with compatible carriers. All carriers shall be commercial or industrial grade and shall be suitable for the fixture served, space available and building construction. All carriers shall extend to the floor and be anchored into the slab.

B. Water closet carriers shall be heavy-duty type, rated for a minimum of 750 lbs.

3. EXECUTION

3.1 EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

B. Verify that electric power is available and of the correct characteristics.

3.2 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

B. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install each fixture with trap with 2 slip joints, easily removable for servicing and cleaning.

C. Provide chrome plated rigid or flexible supplies to fixtures with stops, reducers, and escutcheons.

D. Install components level and plumb.

E. Install and secure fixtures in place with scheduled wall supports or wall carriers and bolts.

F. Seal fixtures to wall and floor surfaces with sealant, color to match fixture.
3.4 WATER CLOSET INSTALLATION

A. Water-Closet Installation:
   1. Install level and plumb according to roughing-in drawings.
   2. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1. Coordinate exact locations with drawings.
   3. Where installing piping adjacent to water closets, allow space for service and maintenance.

B. Support Installation:
   1. Use carrier supports with waste-fitting assembly and seal.
   2. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:
   1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
   2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
   4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
   2. Install deep-pattern escutcheons if required to conceal protruding fittings.

F. Joint Sealing:
   1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to water-closet color.

3.5 URINAL INSTALLATION

A. Urinal Installation:
   1. Install urinals level and plumb according to roughing-in drawings.
   2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
   3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1. Coordinate exact locations with drawings.

B. Support Installation:
   1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:
   1. Install flushometer-valve water-supply fitting on each supply to each urinal.
   2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   3. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
   2. Install deep-pattern escutcheons if required to conceal protruding fittings.

E. Joint Sealing:
   1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to urinal color.

3.6 LAVATORY AND SINK INSTALLATION

A. Install lavatories and sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories and sinks.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1. Coordinate exact locations with drawings.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

E. Seal joints between lavatories/sinks, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks.

G. Install water-supply piping with stop on each supply to each faucet.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with lavatory/sink.
   2. Install stops in locations where they can be easily reached for operation.

3.7 CLEANOUT INSTALLATION
A. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

B. Encase exterior cleanouts in concrete flush with grade.

3.8 WATER HAMMER ARRESTOR INSTALLATION

A. Install water hammer arrestors complete with accessible isolation valve according to PDI-WH 201 and as shown on drawings.

3.9 FLOOR DRAIN INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

B. Position floor drains for easy access and maintenance.

C. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

1. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
2. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
3. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

D. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

3.10 INTERFACE WITH OTHER PRODUCTS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.11 ADJUSTING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

C. Adjust water pressure at flushometer valves to produce proper flow.

D. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
3.12 CLEANING

A. Directly prior to project turnover, clean plumbing fixtures and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets, urinals, and fittings.

C. Do not allow use of plumbing fixtures for use during construction unless approved in writing by Owner.

END OF SECTION 22 40 00
SECTION 22 61 13 – SPECIALTY GAS PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Equipment, accessories, pipe, and pipe fittings for:

1. Specialty Gas systems.
2. Hydrogen Gas systems.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Perform work in accordance with NFPA 99.
2. Brazing Qualifications: Must meet the brazing qualification standard outlined in NFPA 99.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

1.3 REGULATORY REQUIREMENTS

A. Conform to NFPA 99 for Level 1 gas systems and applicable codes for laboratory gas systems.

B. Provide certificate of compliance from authority having jurisdiction indicating approval of systems.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., or other testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

2. PRODUCTS

2.1 PIPE AND FITTINGS
A. Laboratory Specialty Gases (Hydrogen and Hydrogen Mix excluded)

1. Copper Tube: ASTM B 819 Type L, hard drawn, rated for OXY or OXY/MED. Tubing shall be cleaned for oxygen service by the manufacturer and delivered with capped ends.
3. Joints: AWS A5.8 Classification BCuP-3 or BCuP-4 silver braze, without flux to NFPA 99 Level 1 system standards and ASSE series 6000 installation procedure, including clean, dry nitrogen purge.
4. Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

B. Hydrogen Gases and Mixes

1. Stainless steel tube: ANSI/ASME B31.3 process piping, ASTM A269 TP 304, maximum hardness 80 Rb. 0.035-in thickness for pressures up to 275 psi (Sch. 40S)
2. Fittings: Swagelock, Parker, or Hoke with pressure rating up to 7000-psig.
3. Joints: Welded per ASME B31.3. Threaded fittings shall be kept to a minimum.

2.2 VALVES

A. Factory Preparation for Laboratory Gas Service: Disassemble, clean, degrease, seal, and pack for shipping.

B. Ball Valves:

1. Bronze body, three piece, double-seal ball valves with replaceable neoprene or teflon seat and stem seals, for minimum 600 psi cold working pressure, flange or union mounting, labeled for intended service.

C. Check Valves:

1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig minimum.

D. Hydrogen Valves: Shall be full stainless steel as required, austenitic stainless steel only.

2.3 PIPING ACCESSORIES

A. Hangers and Supports: MSS SP-58 with types as required by MSS SP-69.

B. Pressure Gauges:
1. ANSI B40.1, white dials and black lettering with restrictor.
2. Manufactured and labeled expressly for intended service; UL labeled.

2.4 AIR PRESSURE REGULATORS

A. Main Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250 psig inlet pressure. Pilot-operated.

B. Line Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200 psig inlet pressure. Diaphragm-operated.

2.5 FILTER ASSEMBLIES

A. See schedule for further information.

3. EXECUTION

3.1 INSTALLATION

A. Make air cock and drain connection on horizontal casing.

B. Connect condensate drains to nearest floor drain.

C. Install valved drip connections at low points of piping system.

D. Install take offs to outlets from top of main, with shut off valve after take off. Slope take off piping to outlets.

E. Install compressed air couplings, female quick connectors, and pressure gauges where outlets are indicated.

F. Identify piping system and components. Refer to Section 22 05 53.

G. Pre-Installation Cleaning: Disassemble positive pressure gas systems pipe, fittings, valves, and components, except those supplied cleaned and prepared for intended service, and thoroughly wash in hot solution of sodium carbonate or trisodium phosphate mixed 1 lb to 3 gal of water. After washing, rinse with water, dry and cap until installation.

H. Braze joints in pipe and tubing. Avoid leaving excess flux inside of pipe and fittings. During brazing of pipe connections, purge interior of pipe continuously with nitrogen.
I. Effect changes in size with reducing fittings. Make changes in direction of required turns or offsets with fittings or tubing shaped by bending tools. Make bends free of flattening, buckling or thinning of tube wall.

J. Cut pipe and tubing accurately and install without springing or forcing.

K. Grade piping down in direction of flow.

L. Provide pipe sleeves where pipes and tubing pass through walls, floors, roofs, and partitions. Finish flush at both ends. Extend 2 inches above finished floors. Pack space between pipe or tubing and sleeve, and caulk.

M. Support gas piping with pipe hooks or hangers suitable for size of pipe, spaced:
   1. 1/2 inch pipe or tubing or less: 72 inches.
   2. 3/4 inch or one inch pipe or tubing: 96 inches.
   3. 1-1/4 inches or larger (horizontal): 120 inches.
   4. Vertical pipe or tubing: Every floor level.

N. Except where indicated or in flush wall mounted cabinets, install manual shut off valves with stem vertical and accessible for operation and maintenance.

O. Install ball valve at all connections to equipment.

P. Bases and Site preparation
   1. Contractor shall furnish 4 inch high concrete housekeeping pads under all medical air vacuum pumps.
   2. Contractor shall furnish inertia bases in lieu of housekeeping pads where the equipment installed is not factory isolated by the manufacturer.
   3. Cast anchor bolts into bases.

3.2 FIELD QUALITY CONTROL

A. Piping Leak Test: Cap and fill piping system with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate the test source and let stand for four hours to equalize temperature. Refill system, if necessary, to test pressure; hold for two hours with no drop in system pressure.

B. Repair or replace piping as required to eliminate leaks, and retest to demonstrate compliance.

END OF SECTION 22 61 13
SECTION 22 67 00 – DEIONIZED WATER PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and pipe fittings.
B. Valves.
C. Flanges, unions, and couplings.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.
B. References.
C. Submittals.
D. Operation and maintenance manuals.
E. Project record documents.
   1. Record actual locations of valves.
F. Delivery, storage, and handling.

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code and all manufacturer recommendations.

2. PRODUCTS

2.1 DEIONIZED WATER PIPING, ABOVE GRADE (NON-PLENUM APPLICATIONS)

A. Polypropylene Pipe: Manufactured to ASTM D1785 for dimensions and tolerances. Material shall be natural virgin copolymer polypropylene with no added plasticizers, pigments, or re-grind that meets the requirements of ASTM D4101 and is compliant with FDA 21.CFR 177.1520 Sections A1, B and C. Pipe shall be packaged in polybags at the point of manufacturing to preserve cleanliness.
1. Fittings: Fitting material shall be of same type as pipe material. Fittings shall be designed for socket fusion utilizing manufacturer’s recommended fusion tools and shall have a design working pressure of 150 psig at 68°F. Fittings shall be packaged in polybags at the point of manufacturing to preserve cleanliness.

2. Joints: Socket fusion joints. Note that mechanical joints are not allowed.


4. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. PPro-Seal by George Fischer Sloane.
   b. Enpure by IPEX.
   c. Approved equivalent.

B. Low Extractable PVC: UPW process piping shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All pipe shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D1785. All piping shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.

1. Fittings: UPW process fittings shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All fittings shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D2467. All fittings shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.

2. Joints: System components shall be joined utilizing Low Extractable One-Step specialty solvent cement specifically formulated for joining the system that meet or exceed the requirements of ASTM D2564. The standard practice for safe handling of solvent cements shall be in accordance with ASTM F402. Solvent cement shall be NSF-certified for potable water.

3. Pipe, fitting and valve material shall meet or exceed the requirements of ASTM D1784.

4. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. Low Extractable PVC by Spears.

C. Stainless Steel Pipe: Schedule 10, ASTM A312/A312 M, Grade TP316L, seamless pipe.

1. Fittings: ASTM A 403/A 403M, Class S, seamless fittings matching pipe thickness and grade.


D. Supports: All pipe supports shall use the pipe manufacturer’s recommended support system. Support spacing shall be in accordance with the manufacturer’s written instructions and recommendations.

2.2 DEIONIZED WATER VALVES (NON-PLENUM APPLICATIONS)
A. Valves: Material shall be natural virgin copolymer polypropylene with no added plasticizers, pigments, or re-grind that meets the requirements of ASTM D4101 and is compliant with FDA 21.CFR 177.1520 Sections A1, B and C. Valves shall be designed for socket fusion utilizing manufacturer’s recommended fusion tools and shall have a design working pressure of 150 psig at 68°F. Valves shall have two-way blocking capability, blow-out proof stem with double seals, FPM O-rings, PTFE valve seats, and elastomeric backing. Ball shall be full bore type. Valves shall be packaged in polybags at the point of manufacturing to preserve cleanliness.

1. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. PPro-Seal by George Fischer Sloane.
   b. Enpure by IPEX.
   c. Approved equivalent.

B. PVC Valves: All UPW process valves shall be True Union-style diaphragm or True Union-style quarter-turn ball valves produced from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All valve diaphragms and seats shall be PTFE; valve O-rings shall be EPDM or FKM as applicable. All valve union nuts shall have buttress-style threads. All valve components shall be replaceable. All Valves shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.

1. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. Low Extractable PVC by Spears.

C. FLANGES, UNIONS, AND COUPLINGS (NON-PLENUM APPLICATIONS)

D. PVC

1. Construction: Materials shall be a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All fittings shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D2467. All fittings shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.

E. Polypropylene

1. Construction: Material shall be natural virgin copolymer polypropylene with no added plasticizers, pigments, or re-grind that meets the requirements of ASTM D4101 and is compliant with FDA 21.CFR 177.1520 Sections A1, B and C.

2. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. PPro-Seal by George Fischer Sloane.
   b. Enpure by IPEX.
   c. Approved equivalent.
2.3 DEIONIZED PIPING, ABOVE GRADE (PLENUM APPLICATIONS)

A. Polyvinylidene fluoride pipe shall be manufactured from virgin Kynar resin. Pipe 4 inches and smaller shall be manufactured to an SDR (Standard Dimension Ratio) series. Pipe sizes 1/2 inch through 2 inch shall be manufactured to have a pressure rating of 232 psi when measured at 68 F. Pipe internal surface finish shall be Ra 20.0µin. The printed pipe stream on extruded material shall be clearly marked with the UL classified and the applicable UL certificate and pipe markings which shows conformance and certification to ASTM/UL 723 for installation within designated return air plenum areas.

1. Polyvinylidene fluoride fittings shall be manufactured from virgin Kynar resin. Pipe 4 inches and smaller shall be manufactured to an SDR (Standard Dimension Ratio) series. Fittings shall be manufactured for bead and crevice free, infrared or butt fusion joining methods.
2. All components of the pipe and fitting system shall conform to the following applicable ASTM standards, D4101, D638, D2837, D2122, FM 4910, and shall conform to FDA CFR 21 177.1520 (certificate of conformance to be included with shop drawing submittal) USP 25 Class VI (certificate of conformance to be included with shop drawing submittal) and ASME-BPE. All pipe and fittings shall be marked with brand name, product description, code number, material, and dimension and pressure rating information. Fittings shall be embossed with a permanent identification during the production process to ensure full traceability.
5. Manufacturers: Subject to compliance with all specified requirements, provide products by:
   a. SYGEF Standard by George Fischer Sloane.
   b. Asahi-America.
   c. Approved equivalent.

B. Stainless Steel Pipe: Schedule 10, ASTM A312/A312 M, Grade TP316L, seamless pipe.

1. Fittings: ASTM A 403/A 403M, Class S, seamless fittings matching pipe thickness and grade.

C. Supports: All pipe supports shall use the pipe manufacturer’s recommended support system. Support spacing shall be in accordance with the manufacturer’s written instructions and recommendations.

2.4 DEIONIZED WATER VALVES (PLENUM APPLICATIONS)

A. PVDF Valves: Made from ASTM D 3222, PVDF resin.

1. Diaphragm Valves: Diaphragm valves shall be constructed of PVDF with EPDM seal configurations, manufactured for installation in manufacturer’s system.
2. Check Valves: Check Valves shall be constructed of PVDF available in EPDM seal configurations manufactured for installation in manufacturer’s system.
3. Manufacturers: Subject to compliance with all specified requirements, provide products by:
a. Sygef by George Fischer Sloane.
b. ASAHI-America.
c. Approved equivalent.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Route piping in orderly manner and install level and plumb.

C. Install piping to conserve building space and not interfere with use of space.

D. Install hangers spaced as recommended by manufacturer, but free from sags or bends in system.

E. Install padded hangers and support rods spaced as recommended by manufacturer, but in no case less than:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 and NPS 3: 48 inches with 1/2-inch rod.

F. Install padded supports for vertical PP piping NPS 2-1/2 and larger every 120 inches and midstory for NPS 2 and smaller.

G. Group piping whenever practical at common elevations.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Polypropylene piping installation shall only be performed by factory trained and certified installers in accordance with the manufacturer’s written procedures. Each installer shall complete the manufacturer’s certification course, including written test examinations and submittal of test fusion welds to the factory for evaluation and file. Installation practices, including support spacing and expansion considerations, shall be in accordance with the manufacturer’s certification course and written recommendations.

1. The manufacturer shall also provide training and certification for Owner’s personnel at a time separate from the contractor training. Coordinate exact time with Owner.
2. Installer shall adhere to all manufacturer requirements for preheating and fusion times in cold weather.
3. Upon completion of the project, the contractor shall send electrofusion controller/heater (used on polypropylene pipe) back to factory for calibration and necessary repairs prior to delivering to the Owner. Contractor shall be responsible for any expense accrued due to the recertification and repair of the electrofusion controller/heater. Contractor shall also provide all associated components required to maintain the piping system.

4. Contractor shall rent infrared joining machine (used on PVDF pipe). It is not required to hand provide owner with a machine upon project completion.

   a. A similar requirement exists in Section 22 10 00 for laboratory waste piping. If the same controller/heater can be used for the Deionized Water piping and laboratory waste piping, only 1 controller/heater shall be provided to the Owner.

J. Provide clearance for access to valves and fittings.

K. Provide access where valves and fittings are not exposed.

L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

M. Install valves with stems upright or horizontal, not inverted.

N. Install stainless steel pipe and fittings downstream of Deionized Water system ultraviolet sterilizer to protect polypropylene piping from excess sterilizer light. Transition to polypropylene pipe and fittings for remainder of system. See drawings for further information.

3.2 APPLICATION

A. Install polypropylene flanges with backing rings downstream of valves and at equipment or apparatus connections. As an alternative, valves can be used as unions if valve is specifically designed with union ends.

B. Flanged joints, where required, shall be installed per PVDF piping manufacturers’ recommendations using full-face, 1/8-inch thick, EPDM flange gasket. Install and torque stainless steel bolts per PVDF piping manufacturers’ recommendations.

C. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

D. Install ball valves for throttling, bypass, or manual flow control services.

E. Provide spring loaded check valves on discharge of water pumps.

3.3 PIPING SYSTEM PRESSURE TESTING

A. Submit copy of Pipe Pressure Test Log provided in section 22 05 00 for each section of piping tested.
B. Perform hydrostatic pressure test, using purified water, to 100 psig and hold for 4 hours. If system does not hold pressure, repair leaks, then test again. Inform Owner’s Representative a minimum of 2 weeks in advance of pressure test. Note that the use of air or other compressed gases will not be allowed for pressure testing of Deionized Water piping.

C. Leave uncovered and unconcealed all new, altered, extended, or replaced piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.

3.4 PIPE SYSTEM CLEANING
System cleaning shall be completed by the Deionized Water equipment manufacturer. See Section 22 67 01.

END OF SECTION 22 67 00
SECTION 22 67 01 - PURIFIED WATER SYSTEM EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Purified water system equipment.

1.2 RELATED SECTIONS

A. Section 22 67 00 – Purified Water Piping.

1.3 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References
B. Submittals

1.4 QUALITY ASSURANCE

A. See Section 22 05 00.
B. Perform Work in accordance with State and Local standards.
C. Provide pumps with manufacturer’s name, model number, and rating/capacity identified.

1.5 WARRANTY

A. Provide written three-year warranty from the date of Substantial Completion for repair or replacement of purified water system equipment components that fail in materials or workmanship.

2. PRODUCTS

2.1 Refer to Water Purification Equipment Schedule on Drawings for performance requirements.

2.2 All purified water system equipment components shall be provided as part of a package by a single manufacturer. Subject to compliance with the specified requirements, manufacturers offering products that may be incorporated into the package include, but are not limited to:

A. Siemens.
B. Millipore.
2.3 All required system components required to produce the quality and quantity of water listed in the equipment schedule on the drawings shall be provided by the purified water system equipment manufacturer. There shall be no requirement for the Owner to lease any items, such as deionization tanks, carbon filter tanks, etc.

3. EXECUTION

3.1 PURIFIED WATER EQUIPMENT INSTALLATION

A. Install all components in accordance with manufacturer’s instructions.

B. Anchor tanks and floor-mounted equipment to substrate.

C. Pipe relief valves and drains to nearest floor drain.

D. All piping upstream of deionization unit shall be considered domestic cold water. Install per Section 22 10 00.

E. All piping downstream of deionization unit shall be considered purified water. Install per Section 22 67 00.

3.2 FIELD QUALITY CONTROL

A. Manufacturer’s Field Services:

1. Engage a factory-authorized service representative to inspect field assembly of components and electrical connections. Report results in writing.

B. Testing:

1. After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist. See Section 22 67 00 for testing requirements.

2. After purified water system has been leak-tested, the purified water system supplier shall clean the system loop piping, components, and storage tank by circulating a solution of chlorine dioxide and water, in concentration recommended by manufacturer, for a minimum of 2 hours. During circulation, all valves and faucets shall be opened at some point as necessary to clean all portions of the system. Then, rinse with purified water and test for chlorine dioxide level to ensure no residue remains. If residue remains, repeat rinse and retest cycle until all components and piping are free of residue.

3. After electrical connections have been energized, start system and confirm proper operation of all components. Remove malfunctioning units, replace with new units, and retest.
4. Replace damaged or malfunctioning controls and equipment.

C. Sampling:

1. Sample effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics.

D. Contractor Coordination

1. The manufacturer and contractor shall coordinate all work to ensure a fully functional and leak-free system. Permanent labeling shall be provided at the demarcation point between the purified water system piping installed by the Contractor and the purified water system equipment/piping installed by the manufacturer to indicate the responsible party (manufacturer or contractor) for all portions of work in the event of future leaks outside of the warranty period.
2. All purified water system equipment components shall be properly labeled with serial numbers, part numbers, and contact information.

3.3 COMMISSIONING

A. Engage a factory-authorized service representative for a minimum of 16 hours to supervise construction and to perform startup service.

END OF SECTION 22 67 01
SECTION 23 05 00 - BASIC HVAC REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

A. This section describes Basic Mechanical Requirements required to provide for a complete installation of all mechanical systems for this project. This section shall apply to all other Division 23 specification sections as well as all work shown on the drawings.

B. It is the intent of the Mechanical Division of the Specifications that all mechanical work specified herein be coordinated as required with the work of all other Divisions of the Specifications and Drawings so that all installations operate as designed.

C. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation to the satisfaction of the Owner’s representative.

D. The Contractor shall note that, in some cases, piping as shown on the Drawings provide general location and routing information only. The Contractor shall be responsible for providing interference-free systems with proper clearance to facilities and equipment.

E. Where the word “provide” is used, it shall mean “furnish and install” unless otherwise noted or specified.

F. Note that the words “mechanical” and “plumbing” are used interchangeably throughout the Division 22 and 23 specification sections.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section and all other sections of Division 23.

1.3 DESCRIPTION OF WORK

A. The work included under this section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete mechanical systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, piping fixtures, etc. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Architect/Engineer.
before proceeding with the work.

1.4 QUALITY ASSURANCE

A. Installers shall have at least 5 years of successful installation experience on projects with mechanical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation, unless noted otherwise in other mechanical sections.

B. Manufacturer of equipment and materials must be regularly engaged in the manufacture of the specified equipment and material with similar construction and capacities and whose products have been in satisfactory use in similar service for not less than five (5) years, unless noted otherwise in other Mechanical Sections.

C. Qualify welding processes and operators for structural steel according to AWS D1.1. "Structural Welding Code - Steel.

D. Quality welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

E. Comply with provisions of ASME B31 Series "Code for Pressure Piping", including all addenda.

F. Contractor signed welder certificate(s) shall be submitted. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current. A record shall be maintained on the job site showing the date and results of qualification tests for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to the Owner’s representative.

G. For all the refrigerant work/service required by this project, all refrigerant technicians shall be EPA/ASHRAE 34 certified for corresponding classification type I, II, III and/or IV.

1.5 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following as applicable:

1. Safety and Health Regulations for Construction.
2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
4. ACCA - Air Conditioning Contractors of America.
5. ACGIH - American Conference of Governmental Industrial Hygienists.
6. ADC - Air Diffusion Council.
8. AIHA - American Industrial Hygiene Association.
14. ASME - The American Society of Mechanical Engineers.
16. CAGI - Compressed Air and Gas Institute.
17. CTI - Cooling Tower Institute.
18. EJMA - Expansion Joint Manufacturers Association.
19. ETL - Engineering Tests Laboratory.
22. HYD I - Hydronics Institute.
23. ICBO - International Conference of Building Officials.
25. NEBB - National Environmental Balancing Bureau.
27. NEMA - National Electrical Manufacturers Association.
29. NSF - National Sanitation Foundation.
30. SAE - Society of Automatic Engineers.
31. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association.
32. TEMA - Tubular Exchanger Manufacturers Association.
33. UL - Underwriters Laboratories, Inc.
34. International Plumbing Code.
35. International Mechanical Code.
36. Other governing, state, and local codes that apply.

1.6 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections "General Conditions" and "Special Conditions".

B. The Architect/Engineer’s review of submittals, including any corrections or comments made on the shop drawings during the review process, do not relieve Contractor from compliance with requirements of the Contract Documents. The review is only a review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for confirming and correlating all quantities and dimensions; selecting fabrication process and techniques of construction; coordinating his work with that of all other trades; and performing his work in a safe and satisfactory manner. The Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Architect/Engineer’s review of those drawings.

C. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Architect/Engineer. All such portions of the work shall be in accordance with reviewed submittals and the associated manufacturer recommendations.
D. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Plumbing Sections.

1. Certified performance and data with system operating conditions indicated. All coil, fan, and pump performance data shall be computer generated.
2. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
3. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loading, required clearances, and methods of assembly of components.
4. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electrical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of electrical equipment and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
5. Maintenance Data: Submit maintenance data and parts list for each mechanical equipment, control and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

E. Coordination drawings

1. Drawings:
   a. Provide coordination in determining adequate clearance and space requirements for fire protection equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.
   b. Provide coordination drawings indicating structural components, reflected ceiling layout, fire protection items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment. Existing items that are expected to conflict with new work shall also be modeled in the coordination drawings. This applies to all disciplines.
   c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.
   d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the "change order" process.
   e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves.
Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.

2. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination drawing process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:

a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.

b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.

3. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).

a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.

b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):  

1) Roof drain leaders
2) Large waste piping
3) Sprinkler mains
4) Equipment located above the ceiling
5) Heating hot water piping
6) Chilled water piping
7) Conduit runs 2 inches and larger
8) Cable tray
9) Bus duct
10) Recessed light fixtures
11) Building wiring or cable trays
12) Ceiling heights as shown in contract documents and thickness of system
13) Soffits (including framing of supports)
14) Access points and clearances required
15) Access panels
16) Valves
17) Dampers  
18) Coils  
19) Ductwork  
20) Fire-rated wall, partition, and floor penetrations  
21) Steam and condensate piping  
22) Space allotted for future utilities  
23) Equipment in mechanical and electrical spaces

c. Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.

4. The coordination drawings shall be submitted to the Architect/Engineer and Owner’s representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Architect/Engineer, recommended solutions will be provided with the coordination drawings for review by the Architect/Engineer. The Architect/Engineer will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.

5. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Architect/Engineer and the Owner for review on a monthly basis with changes “clouded” and brought to the attention of the Architect/Engineer and the Owner.

6. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Architect/Engineer revisions necessary to the work of others not directly affected by the change order.

7. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

F. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

1.7 SUBSTITUTES

A. Refer to the General Conditions and Special Conditions sections of this Specification for general substitution requirements and information.

1.8 WARRANTY
A. Refer to the General Conditions section of this Specification for general warranty requirements and information. Additional warranty requirements are specified in subsequent Mechanical Sections.

1.9 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Operate each system and item of equipment in a test run of appropriate duration, but no less than 7 days, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Any system placed in temporary operation for testing or for the convenience of the Contractor during construction shall be properly maintained and operated by the Contractor.

C. All systems shall be protected against freezing, flooding, corrosion or other forms of damage prior to acceptance by the Owner.

D. Material or equipment damaged, shown to be defective or not in accordance with the Specifications shall be repaired or replaced to the satisfaction of the Owner’s representative.

E. All tests shall be made after notification to and in the presence of the Owner’s representative.

F. Before starting up any system, each piece of equipment comprising any part of the system shall be checked for proper lubrication and any other condition which may cause damage to the equipment or endanger personnel.

G. After systems have been demonstrated to be satisfactory for 7 consecutive days and ready for permanent operation, all permanent pipe line strainers shall be cleaned, valve and packings properly adjusted, lubrication checked and replenished if required. Temporary piping, etc. shall be removed and openings restored in a permanent manner acceptable to the Owner’s representative.

H. Conduct a walk-through instruction seminar for the Owner's personnel pertaining to the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, maintenance requirements, operational diagrams, temperature control provisions, sequencing requirements, security, safety, efficiency and similar features of the systems. Walk through must be documented as to those attending and subjects covered. Walk through document(s) shall be signed and dated by the contractor's representative and the owner's representative.

1. Provide instruction seminar, minimum 4 hours each, for each of the following items: Air Handling Units, Exhaust Fans, and Heat Recovery Housing.

I. At the time of substantial project completion, turn over the prime responsibility for operation of the mechanical equipment and systems to the Owner’s operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner’s personnel.
1. If any systems are operated prior to substantial completion, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

1.10 RECORD DOCUMENTS

A. Prepare as-built documents in accordance with the requirements in Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in above, indicate the following installed conditions:

1. The Mechanical Contractor shall provide the Owner with as-built drawings for ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units and indicate all devices requiring periodic maintenance or repair, such as control power transformers, LACS panels/routers, field controllers, duct static pressure sensors, piping pressure sensors, etc.

2. All mechanical systems as described in the Specifications and/or shown on the drawings.

3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 23 Section "Mechanical Identification." Indicate actual inverts and horizontal locations of underground piping.

4. Equipment/material locations (exposed and concealed), dimensioned from prominent building lines.

1.11 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer’s printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

2. PRODUCTS (NOT APPLICABLE)

3. EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades,
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compliance labels, and other information needed for identification.

B. Store and handle material and equipment in compliance with manufacturers’ recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Use proper lifting equipment where size/weight requires handling by such means.

D. Comply with manufacturer’s rigging and moving instructions for unloading material and equipment, and moving them to final location.

E. Equipment requiring disassembly for access purposes shall be disassembled and reassembled as required for movement into the final location following manufacturer’s written instructions.

F. Deliver material and equipment as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

G. Mechanical Contractor shall schedule deliveries so as to minimize space and time requirements for storage of materials and equipment on site.

3.2 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

3.3 COORDINATION

A. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Coordinate the mechanical work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.
2. Within the limits indicated on the drawings, the maximum practicable space for operation, maintenance repair, removal and testing of mechanical and other equipment will be provided.
3. Pipes, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, ducts, and similar items shall be located so that they will not interfere with the intended use of other equipment.

C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
D. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

3.4 MECHANICAL INSTALLATIONS

A. All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

B. The location of all equipment and systems shall be coordinated to preclude interferences with other construction.

C. Should interferences occur which will necessitate deviations from layout or dimensions shown on the Drawings, the Architect/Engineer and the Owner’s representative shall be notified and any changes approved before proceeding with the work.

D. Arrange for chases, slots, and openings in other building components during progress of construction to allow for mechanical installations.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

G. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

H. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

I. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Welding, sweating, or brazing operations

1. All cutting, welding, brazing, or sweating operations carried on in the vicinity of, or accessible to, combustible material shall be adequately protected to make certain that a spark or hot slag
does not reach the combustible material and start a fire.

2. When it is necessary to do cutting, welding, brazing, or sweating close to wood construction, in pipe shafts, or other locations where combustible materials can not be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. Position another individual nearby to guard against sparks and fire.

3. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations, or spatter from electric arc operations, a guard shall be kept at the place of work for at least one hour after completion to verify that smoldering fires have not been started.

4. Whenever welding or cutting operations are carried on in a vertical shaft or where floor openings exist, a fire guard shall be employed to examine all floors below the point of the welding or cutting operation. The fire guard shall be kept on duty for at least one hour after completion to verify that smoldering fires have not been started.

5. Before any work involving cutting, welding, brazing, or sweating operations is started, consult with the Architect/Engineer as to particular safety precautions to be employed on the work.

3.5 ACCESSIBILITY

A. All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind.

3.6 LUBRICATION AND TOOLS

A. Provide a fresh charge of lubricant in accordance with manufacturer’s recommendations to all equipment requiring lubrication prior to start-up and maintain lubrication as required until acceptance by Owner.

B. Provide for each piece of equipment any special tools and a list of such tools required for the operation or adjustment of the equipment and turn over to the Owner’s representative prior to final acceptance of the equipment.

3.7 PIPING SYSTEMS PRESSURE TESTING

A. The following personnel in the order listed shall be considered acceptable witnesses of all piping pressure testing:

1. Owner’s Representative
2. Mechanical Engineer / Architect
3. General Contractor’s Foreman

B. Removal of pressure charge and associated drain down shall also be witnessed.

C. Mechanical contractor shall provide a minimum of 24-hour notice to at least one of the above listed parties before commencing any piping systems pressure test.
D. Pressure gauge requirements: Provide recently calibrated gauge with 4” face and a range such that test pressure is between 50% and 100% of gauge range. For example, a gauge with a 15 psig range is acceptable for a 10 psig pressure test, whereas a gauge with a 30 psig range is unacceptable in this application. Gauge resolution shall be suitable for type of testing, system size and test media. Gauge shall have been recently calibrated.

E. All piping pressurizing equipment (i.e., air compressor) shall be disconnected before test is commenced and shall remain disconnected for the entire duration of the test.

F. Entire system shall be properly vented before test is commenced.

G. For specific piping pressure testing requirements and procedures, see applicable piping systems specification sections.

H. Submit completed “Pipe Pressure Test Log” provided at the end of this Section for each pressure test before final project closeout. Test log shall also be included in operation and maintenance manuals.

NOTE: USE MULTIPLE FORMS IF NECESSARY

3.8 EXTENT OF WORK

A. Access Panels

1. Furnish and install panels for access to valves and dampers and similar items where no other means of access, such as readily removable, sectional ceiling is shown or specified.

B. Cutting and Patching

1. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

2. Contractor shall coordinate all cutting and patching of holes, in existing building and new construction which are required for the passage of mechanical work.

3. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.

4. Cut, channel, chase and core drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.

5. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.

6. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.

7. Repair cut surfaces to match adjacent surfaces.

8. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
a. Uncover work to provide for installation of ill-timed work.
b. Remove and replace defective work.
c. Remove and replace work not conforming to requirements of the Contract Documents.
d. Remove samples of installed Work as specified for testing.
e. Install equipment and materials in existing structures.
f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Concrete Bases

1. Minimum 4" high concrete housekeeping pads shall be provided under floor mounted mechanical equipment.
2. Construct concrete equipment bases a minimum 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi, 28-day compressive strength concrete, reinforcement and forms as specified in Division 3 Section "Cast-In-Place Concrete."

D. Painting

1. Contractor is to field paint HVAC equipment and materials in specified areas as noted on the HVAC plans, HVAC schedules and in the specifications.
2. In concealed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted with one coat of zinc rich paint.
3. In exposed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted in accordance with Section 099100.

E. The responsibility of work specified under Division 23 and 26 is clarified under, Section 230513, "Electrical Requirements for Mechanical Equipment. Contractor is to coordinate all electrical requirements prior to ordering powered mechanical equipment.

END OF SECTION 23 05 00
SECTION 23 05 13 - ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Electrical Requirements for:

1. Motors
2. Starters, Electrical Devices, and Wiring
4. Motor Connections
5. Capacitors
6. Safety Switches

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Electrical components and materials shall be UL labeled and listed.

B. References.

1. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:

   a. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
   b. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
   c. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
   d. ANSI/NEMA Standard MG 1 – Motors and Generators.
   e. ANSI/NEPA 70 - National Electrical Code.
   f. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
   g. NEMA Standard 250 – Enclosures for Electrical Equipment.
   h. NEMA Standard KS 1 – Enclosed Switches.

C. Submittals.

1. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, or as required by the individual equipment specification sections.

D. Operation and maintenance manuals.

E. Project record documents.
F. Delivery, storage, and holding

G. Related sections.

1. Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.3 SUMMARY

A. This section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment. In addition, this section covers necessary coordination issues between mechanical and electrical disciplines. All mechanical and electrical construction documents must be completely reviewed by the Mechanical and Electrical Contractors prior to the submission of bids. Any discrepancies in the documents should be brought to the Architect/Engineer's attention at that time. Failure to properly coordinate or review documents in advance of submission of bids will not be valid cause for changes to the overall Contract amount.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

2. PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Minimum service factors shall be as follows:

<table>
<thead>
<tr>
<th>Horsepower:</th>
<th>3600 RPM:</th>
<th>1800 RPM:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/6 – 1/3</td>
<td>1.35</td>
<td>1.35</td>
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<tr>
<td>1/2</td>
<td>1.25</td>
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<td>1 – 1.25</td>
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<tr>
<td>1.5 - 150</td>
<td>1.15</td>
<td>1.15</td>
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</tbody>
</table>
3. Two-speed poly-phase motors shall have two separate windings served by a single point electrical connection to the two speed starter. Two speed starters shall be located at the motor location unless otherwise noted.


5. Starting capability: Frequency of starts as indicated by automatic control system, and not less than five (5) evenly timed starts per hour for manually controlled motors.

   a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit each specific application.
   b. Bearings: Ball or roller bearings with inner and outer shaft seals; re-greasable; designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor; for fractional horsepower, light duty motors, sleeve type bearings are permitted.
   c. Enclosure Type: Unless otherwise noted, use open drip-proof motors where satisfactorily housed or remotely located during operation; guarded drip-proof motors where exposed to contact by employees or building occupants; weather protected Type I for outdoor use, Type II where not housed.
   d. Explosion proof motors shall be provided as indicated on plans and schedules.
   e. Overload protection: Built-in thermal overload protection (in accordance with NEC requirements) and, where indicated, an internal sensing device suitable for signaling and stopping the motor at the starter.

7. Noise rating: "Quiet"

8. Efficiency: "Premium efficiency" motors, as defined in NEMA MG 1, most recent edition.

9. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

10. All three-phase motors shall be inverter duty type.

11. Motors Used With Variable Frequency Drives: Ratings, characteristics, and features coordinated with and approved by drive manufacturer. Motor shall be designed and labeled for use with variable frequency drives. Motor shall be designed with critical vibration frequencies outside the operating range of the drive output and shall be suitable for use throughout speed range without overheating.
   a. Provide AEGIS SGR, or approved equivalent, shaft grounding ring/system to divert adverse shaft currents away from the motor bearings. Use AEGIS Colloidal Silver Shaft Coating (PN CS015), or approved equivalent, prior to ring installation. Install coating and ring per manufacturer recommendations.
12. Motors less than 1 hp: Motor shall be an electronic commutation (EC) motor specifically designed for HVAC applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors. Motors shall be permanently lubricated with heavy-duty ball bearings to match the fan load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

2.2 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor shall be responsible for replacement sheaves required to achieve specified performance. Coordinate with testing and balancing of the equipment.

2.3 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor-Starter Characteristics: Motor starters shall be compatible with the equipment they serve. In general, motor starter characteristics shall meet the requirements of Division 26 specification sections and as outlined as follows:

B. Motor Connections

1. Provide connections to motors in accordance with the requirements listed in the electrical specifications.

2. See Division 26 for the use of lugs for motor connections.

C. Capacitors

1. Capacitor features shall include:
   a. Individual unit cells.
   b. All welded steel housing.
   c. Each capacitor shall be internally fused.
   d. Non-flammable synthetic liquid impregnate.
   e. Craft tissue insulation.
   f. Aluminum foil electrodes
2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

D. FULL VOLTAGE NON-REVERSING MAGNETIC STARTERS
   1. See specification section 26 29 13 – Motor Controllers for requirements.

E. FULL VOLTAGE NON-REVERSING COMBINATION STARTERS
   1. See specification section 26 29 13 – Motor Controllers for requirements.

F. MANUAL MOTOR STARTERS

G. See specification section 26 29 13 – Motor Controllers for requirements.

H. CAPACITORS
   1. Capacitor features shall include:
      a. Individual unit cells.
      b. All welded steel housing.
      c. Each capacitor shall be internally fused.
      d. Non-flammable synthetic liquid impregnate.
      e. Craft tissue insulation.
      f. Aluminum foil electrodes
   2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

2.4 SAFETY SWITCHES
   A. See specification section 26 05 01 – Basic Electrical Materials and Methods.

3. EXECUTION

3.1 INSTALLATION
   A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.
ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer’s requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer’s instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer’s recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

3.2 CONTRACTOR COORDINATION

A. General contractor is responsible for coordination of all subcontractors and associated scopes of work.

END OF SECTION 23 05 13
SECTION 23 05 19 – HVAC METERS AND GAGES

1. GENERAL

1.1 SECTION INCLUDES

A. Chilled Water Meters

B. Pressure gages and pressure gage taps.

C. Thermometers and thermometer wells.

D. Piping pressure and temperature test plugs.

E. Static pressure and filter gages.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Accurately record actual locations of instrumentation.

F. Delivery, storage, and handling

2. PRODUCTS

2.1 CHILLED WATER METERS

A. See Mechanical Equipment Schedules for any specific performance requirements.

B. Magnetic Flow Meter
1. The Magnetic Flowmeter flow tube and computer/transducer shall come as a complete system assembled by a single manufacturer. The flowmeter shall be suitable for use in the accurate measurement of Chilled Water flow for process control and/or utility metering, in a mechanical room environment, with a Johnson Controls EMCS system.

2. The flowmeter shall consist of a pulsed DC electromagnetic coil incorporating Faraday's Law utilizing the flowing Water as the conductor. The flowmeter shall provide proper grounding for use in Schedule 40 steel pipe, Schedule 10S stainless steel pipe, or copper pipe as application requires.

3. The flowmeter element should be sized to maintain maximum accuracy over the flow range of the application while keeping flow tube velocity below 15 fps at max flow. The flowmeter element shall be the flow tube, spool piece type with a non-conductive lining and no intrusions into the flow path. The flowmeter flow tube shall be suitable for direct mounting to standard ANSI flanges.

4. The flowmeter shall have a local LCD display that indicates flow in GPM and/or Total gallons from the totalizer. The flowmeter shall be programmable/configurable via local push buttons. The flowmeter computer/transducer shall be remote mounted. The flow tube shall have a direct mounted junction box for wiring connections.

5. The flowmeter shall have the capability to be calibrated in situ to verify proper operation and accuracies.

6. The flowmeter shall also meet the following specifications:

   a. Measures Bi-directional flow.
   b. Zero-point stability.
   c. Flow tube can withstand a full vacuum on an intermittent basis.
   d. Normal obstructions, partially opened valves, 900 or 450 elbows, and pump discharges shall require no more than 5 pipe diameters upstream and 3 pipe diameters downstream of straight pipe run for specified performance.
   e. Auto re-start after electrodes have lost wetness.
   f. Computer/transducers shall be interchangeable to multiple flow tubes without affecting the published accuracies of the meter.
   g. Computer/transducer internal electronic components, including power supply and output boards, shall be field interchangeable/exchangeable.
   h. Calibration: NIST Traceable, certificate provided with each meter.
   i. Electrode Pressure Rating: Equivalent to flow tube flange rating
   j. Minimum Conductivity: \( 5 \, \text{S/cm} \) for fluid to be measured
   k. Transmitter Ambient Temp.: 122 0F
   l. Flow Tube Process Temp.: 32 0F to 140 0F for Chilled Water applications
   m. Flow Tube Process Temp.: 32 0F to 140 0F for Make Up Water applications
   n. Flow Tube Process Temp.: 32 0F to 311 0F for Hot or Dual Water applications
   o. Flow Range: +/- 0 to 30 fps
   p. Accuracy (velocity \(< = 1.0 \, \text{fps})\): +/- 0.5% of reading or +/- 0.005 fps
   q. Accuracy (velocity \(> 1.0 \, \text{fps})\): +/- 0.5% of reading
   r. Analog Output: 4-20 mA, linear to flow in GPM
   s. Analog Output Accuracy: +/- 0.05% of span
   t. Repeatability: +/- 0.1%
   u. Stability: +/- 0.1%
   v. Ambient Temperature Effect: <1% per 100 0F
   w. Vibration Effect: 0.1% (remote mounted transducer)
x. Low Flow Cutoff: settable to 0.04 fps or lower
y. Low Flow Cutoff Analog Output: Analog output shall be 4.0 mA at flows below the low cutoff.
z. Humidity Limits: 5-90% RH
aa. Power Supply: 115 VAC
bb. Power Consumption: 20 W maximum
cc. Enclosures: NEMA 4
dd. Flow Tube working pressure: 150 psi
ee. Flanges: Carbon steel, ANSI Class 150#
ff. Electrodes: Corrosion resistant Alloy C
gg. Cable Length: 100ft

7. The flowmeter shall be Onicon F-3500 or approved equal.
8. Bids/Submittals: All bids and/or submittals must include published specifications, specific model number configurations, and operation & maintenance manuals.

C. Warranty: All parts and components as needed for the specified operation and performance shall be covered under warranty for a period of not less than two years.

2.2 PRESSURE GAUGES


B. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection, liquid-filled.

C. Case: Drawn steel or brass, glass lens, 4-1/2 inches diameter.

D. Connector: Brass, 1/4-inch NPS.

E. Scale: White coated aluminum, with permanently etched markings.

F. Accuracy: Plus or minus 1 percent of range span.

G. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.3 PRESSURE GAUGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.
2.4 GLASS THERMOMETERS


B. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

C. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red reading, magnifying lens, with non-mercury fluid.

E. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

F. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

G. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

H. Scale range: Temperature ranges for services listed as follows:
   1. Heating Water: 30 to 250 deg with 2-degree scale.
   2. Chilled Water: 0 to 100 deg F with 2-degree scale divisions.
   3. Steam and Condensate: 50 to 400 deg F with 2-degree scale divisions.

2.5 THERMOMETER WELLS

A. Thermometer Wells: Brass or stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

2.6 PIPING PRESSURE AND TEMPERATURE TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

2.7 STATIC PRESSURE GAUGES

A. Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.

B. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

C. Construction: Bronze or stainless-steel body, with sight glass and ball indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 150 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 PRESSURE GAUGES

A. Install pressure gauges in piping tee with pressure gauge valve, located on pipe at most readable position.

B. Install as shown on plans, and elsewhere as indicated.

C. Pressure Gauge Ball Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.3 THERMOMETERS

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install as shown on plans and elsewhere as indicated.
C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

3.4 TEST PLUGS

A. Test Plugs: Install where indicated, located on pipe at most readable position. Secure cap.

3.5 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer’s touch-up paint.

END OF SECTION 23 05 19
SECTION 23 05 29 – HVAC HANGERS AND SUPPORTS

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe, ductwork, and equipment hangers, supports, anchors, saddles and shields.

B. Mechanical flashing.

C. Equipment roof supports.

D. Mechanical sleeves and seals.

E. Flashing and sealing equipment and pipe stacks.

F. Sealants, firestop insulation, putty and compounds.

G. Pipe Stands

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

2. PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Hydronic Piping:

1. Conform to International Mechanical Code, ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89 as applicable.
B. Refrigerant Piping

1. Conform to International Mechanical Code, ASME B31.1, ASTM F708, MSS SP58, MSS SP69, MSS SP89, as applicable.

C. Hangers and Supports:

1. Hangers for Hot and Cold Pipe Sizes 1/2 to 1-1/2 Inch, Carbon steel, adjustable swivel, band type.
2. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
3. Hangers for Hot Pipe Sizes 2 to 4 Inches; Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
7. Wall Support for Hot Pipe Sizes 6 Inches (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Roof Support for Hot and Cold Pipe: See PIPE STANDS section below.
16. Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 23 07 19.
17. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar joist construction, to attach to top flange of structural shape.
18. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
19. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
20. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
21. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
22. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
23. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
24. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
25. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
26. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
27. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
28. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
29. See Section 23 05 48 for vibration isolation hangers and supports if applicable.

2.2 DUCTWORK HANGERS AND SUPPORTS

A. Strap and Rod Sizes: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

B. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

C. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:


2.3 ACCESSORIES

A. Hanger Rods: ASTM A36 steel or galvanized threaded both ends, threaded one end, or continuous threaded.

1. Ductwork: Use double nuts and lock washers on threaded rod supports.

2.4 INSERTS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Internally Threaded Screw Anchors: Internally threaded, self tapping screw anchors, Power Fasteners Snake or approved equivalent.
2.5 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Metal Counterflashing: 22 gage galvanized steel.

C. Lead Flashing:
   1. Waterproofing: 5 lb/sq ft sheet lead
   2. Soundproofing: 1 lb/sq ft sheet lead.

D. Flexible Flashing: 47 mil thick sheet buty; compatible with roofing.

E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.6 EQUIPMENT ROOF SUPPORTS

A. Fabrication: Welded 18 gage galvanized steel shell and base, mitered 3 inch cant, variable step to match roof insulation, 1-1/2 inch thick insulation, factory installed wood nailing. Minimum 24 inch height above top of insulation (not the roof structure).

2.7 SLEEVES

A. Sleeves for Pipes Through Rated Floors and Walls: Schedule 40 steel pipe.

B. Sleeves for Pipes Through Non-Rated Floors: Schedule 40 steep pipe, extended 2” above floor.

C. Sleeves for Pipes Through Non-Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel, extended 2” above floor. See drawings for further detail.

D. Sleeves for Round Ductwork: Galvanized steel, or as shown on drawings.

E. Sleeves for Rectangular Ductwork: Galvanized steel, or as shown on drawings.

2.8 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

A. Refer to Section 07 84 13 for firestopping materials and methods. Refer to drawings for additional details.

B. Sealants:
1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

C. All fire-rated sealants and firestops shall be installed by a certified firestop contractor. Reference front-end specifications for further information.

2.9 MECHANICAL SEALS

A. Mechanical Seals: Modular mechanical type, consisting of interlocking low durometer EPDM synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with type 316 stainless steel bolts and reinforced plastic polymer pressure plates which cause rubber sealing elements to expand when tightened, providing a watertight and gas-tight seal and electrical insulation. Provide Advance Products & Systems Model Innerlynx, Link-Seal LS-316, or approved equivalent.

1. Provide high-temperature silicone links rated for 400 Deg. F for steam and condensate applications.
2. A sleeve shall be provided for each mechanical seal.
   a. Thermoplastic sleeves: Sleeve shall have smooth walls and shall be made of molded non-metallic high density polyethylene (HDPE) with an integral solid water stop, Advance Products & Systems Model PWS, Century-line Model CS, or approved equivalent.
   b. Steel sleeves: Sleeve shall have smooth walls, shall be made of Schedule 40 steel with an integral welded solid water stop, and shall have corrosion-resistant coating, Advance Products & Systems Model GWS, Century-line Model WS, or equivalent.

2.10 PIPE AND DUCT STANDS (ROOF)

A. General Requirements for Pipe and Duct Stands: Shop or field –fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping and ductwork.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   2. Base: Plastic
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel with plastic or stainless-steel, roller-type pipe support.
D. High-Type, Multiple-Pipe or Ductwork Stand:

1. Description: Assembly of Bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic
3. Vertical Members: Two or more protective-coated-steel channels.
5. Pipe Supports: galvanized-steel, clevis-type pipe hangers.

E. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe or duct supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Support fire protection systems piping independently from other piping systems. Fire main piping may be trapezed with other piping systems. Coordinate trapeze hangers with the Sprinkler Contractor.

1. Reference sections 21 05 29 and 22 05 29 for additional information regarding fire protection and plumbing piping supports and hangers.
C. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

D. Place hangers within 12 inches of each horizontal elbow.

E. Use hangers with 1-1/2 inch minimum vertical adjustment.

F. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

I. Support riser piping independently of connected horizontal piping.

J. Provide copper plated hangers and supports for non-insulated copper pipe.

K. Design hangers for pipe movement without disengagement of supported pipe.

L. Prime coat steel hangers and supports in the mechanical room and other exposed areas. Refer to the Architectural reflected ceiling plans for location of exposed ceilings. Hangers and supports located in attic space, crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

M. Adjust hangers to distribute loads equally on attachments and to achieve specified pipe slopes.

N. Saddles, Shields and Inserts

1. Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

2. Install protective shields MSS Type 40 on cold piping that has vapor barrier. Shields shall span an arc of 180 degrees (360 degrees on trapeze hangers with U-bolt clamps) and shall have dimensions in inches not less than the following:

<table>
<thead>
<tr>
<th>NPS</th>
<th>LENGTH</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 through 3-1/2</td>
<td>12</td>
<td>0.048</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>0.060</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>18</td>
<td>0.060</td>
</tr>
<tr>
<td>8 through 14</td>
<td>24</td>
<td>0.075</td>
</tr>
<tr>
<td>16 through 24</td>
<td>24</td>
<td>0.105</td>
</tr>
</tbody>
</table>

3. Pipes 8 inches and larger shall have wood inserts.
4. Insert materials shall be at least as long as the protective shield.
5. Provide manufacturer-recommended saddles, inserts, and/or shields where cellular foam insulation is used. The removal of sections of cellular foam insulation for the purpose of pipe support is not acceptable.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.
Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.6 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls and floors.

B. Flash drains in floors with topping over finished area with lead, inches clear on sides with minimum 36 x 36 inch sheet size. Fasten to drain clamp device.

C. Seal floor, shower, mop sink, etc. drains watertight to adjacent materials.

D. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

E. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 SLEEVES

A. Provide pipe and duct sleeves at all fire/smoke rated partitions, exterior wall penetrations and wall penetrations into exposed areas. Pipe and duct sleeves are not required for penetrations through non-rated concealed partitions.

B. At the Contractor's option, pipe sleeves may be omitted if the wall or floor is core drilled.

C. Set sleeves in position in formwork. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Sleeves through floors shall be grinded flush with finish floor level.

F. Where piping or ductwork penetrate non-rated ceilings or walls, close off space between pipe or duct and adjacent work with urethane rod stock and caulk air tight.

G. Seal pipe and duct penetrations through non-rated floors.

1. Where piping is not located in a rated shaft and it penetrates a single non-rated floor, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.
2. Where piping is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between pipe and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.

3. Where ductwork is not located in a rated shaft and it penetrates a single non-rated floor, close off space between duct and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.

4. Where ductwork is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between duct and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound. Install fire damper in duct at each floor level. Ductwork containing fume exhaust air shall not be provided with fire dampers.

H. Where piping or ductwork penetrate rated floor, ceiling, or wall, close off space between pipe or duct with appropriate fire rated sealant, insulation, putty or compound. Refer to the Drawings for fire/smoke rated wall locations and the appropriate ratings.

I. Provide on ductwork close fitting metal collar or escutcheon covers on the side of penetration that are exposed to view.

J. Install chrome plated steel escutcheons on piping at finished surfaces.

K. Waste, vent and storm pipe penetrations through the concrete floor slab shall be encased in the poured concrete slab.

L. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.

3.8 EQUIPMENT ROOF SUPPORTS

A. Provide a minimum of two equipment roof supports for each roof-mounted equipment item that does not have integral equipment rails that would extend the bottom of the equipment a minimum of 24” above the roof insulation. Coordinate location of roof supports with equipment manufacturer.

B. Provide all necessary sealants and flashing required for a waterproof installation. Coordinate with roof manufacturer and other trades.

3.9 HANGER SCHEDULES

A. Reference International Plumbing Code and International Mechanical Code where applicable.

END OF SECTION 23 05 29
SECTION 23 05 48 – HVAC VIBRATION CONTROLS

1. GENERAL

1.1 Coordinate requirements of this specification with all other specifications and trades. Requirements of this specification take precedence over other specification sections. For example, the requirements of this section with regard to pipe supports in mechanical rooms take precedence above the requirements of Section 23 05 29.

1.2 This specification pertains to the furnishing and installation of vibration isolation devices for rotating or reciprocating mechanical equipment and piping and conduit systems attached thereto, and electrical transformers and attached switchgear and conduit systems.

1.3 This work shall include all material and labor required for installation of the resilient mounting and suspension systems, adjusting each mounting system, and measurement of isolator system performance when so requested by the Architect. Specific mounting arrangements for each item of mechanical and electrical equipment shall be as described herein and as indicated by schedules and details on the drawings.

1.4 All vibration isolation equipment except for resilient pipe connectors, including steel framing and reinforcing for concrete inertia bases and including steel rail bases, shall be furnished by Mason Industries or Kinetics Noise Control. A single manufacturer for all vibration isolation equipment in Sections 22 05 48, 23 05 48, and 26 05 48 will be required except as specifically approved in writing by the Architect or by his specific approval of shop drawings or as specified herein. For resilient pipe connectors refer to provisions of this specification that follow.

1.5 SECTION INCLUDES

A. Vibration isolation systems.

1.6 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

C. Delivery, storage and handling

1.7 ADDITIONAL REQUIREMENTS

A. The Contractor and the vibration isolation manufacturer or his regularly designated and factory authorized representative shall perform the following tasks in addition to the supply and installation of isolation equipment:
1. Obtain from the Architect the approved manufacturer's name, model number, and other necessary identifying data for each item of mechanical and electrical equipment to be resiliently mounted. Coordinate all resilient mounting systems with the exact equipment to be furnished in regard to physical size, isolator locations, weight, rotating speed, etc. Direct contact and cooperation between the vibration isolation device fabricator and the equipment manufacturer will be required.

2. Obtain all necessary data in regard to piping systems which are to be resiliently supported so that proper isolators can be selected. Select piping system isolators for proper coordination with the physical arrangement of pipe lines and with the physical characteristics of the building.

3. Submit shop drawings as required by other portions of this specification. These drawings shall include specification information as follows:
   a. Manufacturer's model number for each isolator, the machine or pipeline to which it is to be applied, and the number of isolators to be furnished for each machine or pipeline.
   b. For steel spring mounts or hangers - Free height, deflected height, solid height, isolator loading, and diameter of spring coil.
   c. For elastomer or glass fiber isolators - Free height, deflected height, and isolator loading.
   d. Dimensional and weight data for concrete inertia bases, steel and rail bases, and details of isolator attachment.

4. Provide on-the-job supervision as required during installation of resiliently mounted equipment and piping to assure that all vibration isolators are installed in strict accordance with normally accepted practices for critical environments.

5. Replace at no extra cost to the Owner any isolators which do not produce the required deflection, are improperly loaded above or below their correct operating height, or which in any way do not produce the required isolation.

6. Cooperate with all other Contractors engaged in this project so that the installation of vibration isolation devices will proceed in a manner that is in the best interests of the Owner.

7. Notify the Architect of any project conditions which affect vibration isolation system installation or performance and which are found to be different from conditions indicated by the drawings or described by the specifications. Should vibration isolation system installation proceed without such notifications any remedial work required to achieve proper isolator performance shall be accomplished by the Contractor at no additional cost to the Owner.

8. Be alert for possible "short-circuiting" of vibration isolation systems by piping supports, electrical connections, temperature control connections, drain lines, building construction, etc., and notify the involved contractor as to these problems or potential problems. Where such situations cannot be easily resolved, notify the Architect so that preventive or remedial action can take place on a timely basis. Any remedial measures required shall be undertaken by the contractor responsible at no additional cost to the Owner.

9. This specification does not include provisions for seismic restraints that might be required by isolations systems due to the geographic location of the project, building codes, or other considerations.

2. PRODUCTS

2.1 VIBRATION ISOLATION SYSTEMS:
1. General:
   a. The vibration isolation systems described herein and identified by type letter designations shall be applied to specific classifications of mechanical and electrical equipment as indicated by Section C of this document.
   b. The minimum static deflection of the isolators for each classification of mechanical or electrical equipment shall be as indicated by Section C of this document or as otherwise indicated herein.

2. Type A Isolation:
   a. The equipment shall be rigidly mounted on a large reinforced concrete inertia base which has length and width dimensions approximately 20% greater than the supported equipment. The inertia base and equipment shall be supported by steel spring vibration isolators. Brackets for the spring isolators shall be located off the sides of the inertia base or integral with the perimeter of the inertia base with the tops of the springs near the vertical center of gravity of the equipment and inertia block; or if the center of gravity is higher than the top of the inertia base, the tops of the springs shall be at the top of the inertia base. The spring isolators shall rest on curbs or pedestals if necessary. There shall be a 2 inch minimum space between the bottom of the inertia base and the top of the housekeeping pad or floor slab when a housekeeping pad is not indicated to be employed.
   b. Concrete inertia bases shall be formed by a welded steel channel frame which incorporates prelocated equipment anchor bolts, and reinforcing bars in each direction welded in place. Concrete shall be standard 150-160 lb/cu.ft. structural concrete. The base thickness shall be determined by the weight requirements but it shall be a minimum of 8% of the longest span between isolators or 6 inches, whichever is greater. For centrifugal and axial fans and centrifugal pumps the inertia base shall have a minimum weight equal to that of the isolated equipment. For reciprocating equipment the inertia base shall have a minimum weight equal to twice the weight of the equipment.
   c. Springs shall be of the free standing unhoused type. Horizontal spring stiffness shall not be less than 0.8 of vertical stiffness. Springs shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection of each spring shall not be less than that specified for each classification of mechanical equipment. The spring deflection from the point of rated deflection to the point at which the spring is solid shall not be less than 1/2 of the rated static deflection. The yield point of the steel used in the springs shall be sufficiently great so that the springs may be compressed to shorted turns without danger of spring failure. At least two layers of ribbed waffle pattern neoprene pads or equivalent glass fiber pads shall be installed under the base plate of each spring isolator. Springs shall have leveling bolts and proper means for bolting to the machines. To prevent corrosion, springs for outdoor installation shall be galvanized or otherwise coated as approved by the Architect.

3. Type B Isolation:
a. The equipment shall be rigidly mounted on wide flange or channel structural steel members which shall run perpendicular to any support channels or similar members which are an integral portion of the equipment, or which shall be fabricated to form a complete frame for machine mounting. Height saving spring mounting brackets shall be welded to the ends of the structural steel saddle members or to the sides of structural steel frames to attach free standing steel spring isolators. Unless otherwise approved, the depth of the structural steel saddle members or the perimeter members of mounting frames shall be at least one-tenth of the longest frame dimension.

b. Steel spring isolators shall be as specified for Type A isolation.

c. Minimum clearance between the steel base and the housekeeping pad or floor shall be 2 inches.

4. Type C Isolation:

a. The equipment shall be rigidly mounted in a steel frame which is sufficiently stiff so that it may be supported on resilient isolators without distortion of the frame or misalignment of the equipment. If the equipment has an integral frame which is suitably rigid, the resilient isolators may be secured directly to the integral equipment frame or base.

b. Isolators shall be selected on the basis of the required static deflection as scheduled or otherwise indicated, and as follows:

1) Required deflection 0.25 to 0.4 inches - double deflection neoprene-in-shear isolators.

2) Required deflection 0.5 inches and greater - steel spring isolators as specified for the Type A mounting.

c. Isolators shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection shall not be less than that specified for each classification of equipment.

d. Minimum clearance between the equipment base and the housekeeping pad or floor shall be 2 inches.

5. Type D Isolation:

a. The equipment shall be mounted on resilient "pads". These pads shall be multiple layers of waffle or ribbed neoprene, neoprene and cork sandwich, or precompressed glass fiber with height and stiffness as required to provide the static deflection as scheduled or specified and as required to properly support the load.

b. Pads shall be loaded in accordance with the manufacturer's recommendations and sized to achieve this recommended loading. The equipment weight at each supporting point shall be considered in selecting pad dimensions along with the recommended loading.

6. Type E Isolation:
a. The equipment shall be suspended with steel spring vibration isolators which are complete with neoprene-in-shear isolators for high frequency noise control. The neoprene-in-shear isolators shall provide static deflection of 0.20 inches minimum. In addition, elastomer washers shall be furnished as necessary to prevent metal-to-metal contact.
b. Hanger rod misalignment of up to 15 degrees relative to vertical shall not cause "short-circuiting" of the isolation components due to metal-to-metal contact.
c. Spring hangers shall utilize free standing springs which are unhoused except for the required partial and open housing assembly. Spring hangers shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection of each hanger shall not be less than that specified for each classification of mechanical equipment. The spring deflection from the point of rated deflection to the point at which the spring is solid shall not be less than one-half of the rated static deflection. The yield point of the steel used in the springs shall be sufficiently great so that the springs may be compressed to shorted turns without danger of spring failure.
d. Resilient hangers shall be installed as near as possible to the supporting overhead structure. The machine suspension points shall be in a rigid and heavy portion of the building structure. Suspension of machines from lightweight floor slabs shall be avoided, particularly at the center of structural spans.
e. Suspension rods shall be attached to rigid members of the machine structure. When such attachment points do not exist, a heavy steel framework shall be furnished to support the machine with suspension rods attached to this framework.

7. Type F Isolation:

a. The equipment shall be suspended with double deflection neoprene-in-shear hangers which are complete with elastomer washers as required to prevent metal-to-metal contact.
b. Hangers shall be installed as near as possible to the supporting overhead structure. Suspension points shall be on a rigid portion of both the overhead structure and equipment framework.

8. Type G Isolation:

a. This mounting shall be the same as the Type E mounting except that the suspended machine shall be supported by a concrete inertia base. Suspension rods shall be attached to the concrete base.

9. Type K Isolation (Curb Mounted Roof-top Air Conditioning Machines):

a. The roof-top air conditioning machine shall be mounted on a free standing steel spring isolated rectangular rail (curb) system. The isolation system shall be suitable for outdoor unprotected locations and it shall include a soft and flexible elastomer air and water seal which shall not short circuit the spring isolators. The isolation system shall not allow lateral movement greater than 5/8 inch for wind loads up to 100 miles per hour. Suitable systems of this type are Kinetics Noise Control Type ESR and Mason Industries Type RSC.
10. Type L Isolation (Water Chillers and Similar Equipment):
   a. Same as Type C except that steel spring isolators shall employ vertical limit stops with provisions to prevent short circuiting of the limit stops when the springs are loaded normally.

3. EXECUTION

3.1 GENERAL

   A. Install in accordance with manufacturer's instructions.

3.2 EXAMINATION

   A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

   B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

   A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

   B. Equipment Restraints:

      1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

   C. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

   D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

   E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

   F. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer’s recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust active height of spring isolators.

C. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 RESILIENT MOUNTINGS FOR SPECIFIC CLASSIFICATIONS OF MECHANICAL EQUIPMENT:

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>ISOLATION TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU</td>
<td>C and Internal Isolation (see AHU specs)</td>
</tr>
<tr>
<td>Base Mounted Pumps</td>
<td>A</td>
</tr>
</tbody>
</table>

3.6 ISOLATION OF PIPING SYSTEMS:

A. All piping and rigidly connected devices such as pressure reducing valves which connects to resiliently mounted equipment shall be suspended with resilient hangers or supported by floor mounted isolators for a distance of 100 pipe diameters from the connected machine or within the mechanical equipment room, whichever is the greater distance. The first three supports from the connected machine shall have the same static deflection as indicated for the machine; the next two supports shall have static deflection at least equal to one-half of the static deflection indicated for the machine mounting, and remaining pipe supports shall provide static deflection of 0.35 inches minimum. These remaining isolators may be elastomer.
HVAC VIBRATION CONTROLS

B. Steel spring hangers shall be as specified for Type E isolation except that a scale shall be attached to the hanger housing to indicate deflection. Elastomer hangers shall be as specified for Type F isolation. Floor mounts shall be free standing steel spring isolators as specified for Type A isolation where static deflection in excess of 0.35 inches is required. Floor mounts, where static deflection of 0.35 inches or less is required, shall be double deflection neoprene-in-shear as specified for Type C isolation.

C. Vertical pipe risers shall be resiliently mounted, preferably with each riser anchored near the center of the run. The risers shall be supported at the anchor points with steel spring or double deflection neoprene-in-shear isolators which provide static deflection of at least 0.35 inches. Isolators for the remainder of each run shall be steel spring type specifically designed to control load shifting due to pipe expansion and contraction. At least 0.35 inches deflection shall be maintained under all conditions.

D. Flexible synthetic rubber connectors shall be used to connect all piping to all isolated equipment. Flexible synthetic rubber connectors shall be fabricated using peroxide cured EPDM synthetic rubber and Kelvar tire cord reinforcement and shall be Mason Industries Safeflex of the most current design. Resilient connectors shall be selected for the pressure rating and temperature rating appropriate for the particular piping and pipe contents. Where synthetic EPDM flexible connectors are not permitted by code due to pipe contents and/or pressures provide swing pipe connectors changing direction a minimum of 3 times before joining isolated equipment. Swing connections should be made within approximately 6 feet of the isolated equipment.

E. Drain connections from isolated equipment to floor drains shall be at least 1” free from drain or use rubber hose.

3.7 ISOLATION OF AIR SUPPLY AND RETURN DUCTS

A. Sheet metal air handling ducts shall be connected to air handlers with resilient connectors and such ducts shall be suspended with resilient hangers or supported by floor mounted isolators for a distance of 30 feet from the connected machine or within the mechanical equipment room whichever is the greater distance. The first three supports from the connected machine shall have the same static deflection as indicated for the machine; the next two supports shall have static deflection at least equal to one-half of the static deflection indicated for the machine mounting, and remaining pipe supports shall provide static deflection of 0.35 inches minimum. These remaining isolators may be elastomer.

B. Steel spring hangers shall be as specified for Type E isolation. Elastomer hangers shall be as specified for Type F isolation. Floor mounts shall be free standing steel spring isolators as specified for Type A isolation where static deflection in excess of 0.35 inches is required. Floor mounts, where static deflection of 0.35 inches or less is required, shall be double deflection neoprene-in-shear as specified for Type C isolation.

3.8 ISOLATION OF FRACTIONAL HORSEPOWER EQUIPMENT:
A. All fractional horsepower fans, pumps, etc., which are mounted on or suspended from floors that are not on-grade shall be isolated with neoprene-in-shear isolators furnished by the vibration isolation supplier except where such isolators are furnished as an integral part of the machine.
SECTION 23 05 53 - HVAC IDENTIFICATION

1.  GENERAL

1.1  SECTION INCLUDES

A.  Nameplates.

B.  Tags.

C.  Pipe Markers.

D.  Ceiling Tacks/Stickers.

E.  Duct Markers.

1.2  REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A.  Quality assurance.

B.  References.

C.  Submittals.

D.  Operation and maintenance manuals.

E.  Project record documents

1.  Record actual locations of tagged valves.

F.  Delivery, storage, and handling.

2.  PRODUCTS

2.1  NAMEPLATES

A.  Equipment Mark Nameplates: Laminated three-layer plastic with engraved black letters (matching equipment mark indicated on drawings) on light contrasting background color, with minimum 3/4 inch high letters.

B.  Equipment Nameplates: Factory-applied permanent nameplate indicating the manufacturer’s name, model, serial number, temperature and pressure design, and any other data necessary to conform
with specified requirements. On equipment installed outdoors, nameplate shall be stamped steel or engrave plastic.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.

B. Chart: Typewritten list that is plastic laminated and mounted in mechanical room. Valve list is to coordinate with mechanical piping schematics if provided on plans.

C. Pipe Schematics: Valve numbers are to be labeled on Engineer schematic drawings, plastic laminated and schematic shall be mounted in mechanical room.

2.3 PIPE MARKERS

A. Color: Conform to ASME A13.1, latest revision

B. Plastic Tape Pipe Markers: Minimum 1-1/2” letter size and 2-mil thickness, flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings; minimum information indicating flow direction arrow and identification of fluid being conveyed.

2.4 CEILING TACKS/STICKERS

A. Description: ½” self adhesive color coded stickers.

B. Color code as follows:

1. Yellow - HVAC equipment
2. Red - Fire dampers/smoke dampers, sprinkler/standpipe system valves
3. Green - Plumbing valves
4. Blue - Heating/cooling valves

2.5 DUCT MARKERS

A. Plastic Tape Duct Markers: Minimum 1-1/2” letter size and 2-mil thickness, flexible, vinyl film tape with pressure sensitive adhesive backing and printed marking; minimum information indicating flow direction arrow and identification of air system being conveyed.

3. EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.
3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic tape pipe and duct markers in accordance with manufacturer's instructions. Directional arrow tape shall be overlapped to ensure proper adhesion and no peeling of tape in future.

D. Identify air handling units, exhaust fans, chillers, pumps, heat generating, heat rejecting, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

E. Identify pressure reducing valves, backflow preventers, valves, and meters with tags.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify valves in main and branch piping with tags.

H. Tag automatic controls, instruments, and relays. Key to control schematic.

I. Identify piping, concealed or exposed, with plastic tape pipe markers. Identify service, flow direction, and pressure when applicable, i.e. low pressure steam, high pressure steam. Install in clear view from floor and align with axis of piping. Locations of identification not to exceed 15 feet on straight runs including risers and drops, more often in congested areas, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Provide a minimum one label per pipe per room. Where pipes are racked, install pipe markers on each pipe in the same location to aid in differentiating each pipe in the rack.

J. Provide ceiling stickers or machine generated labels to locate valves, dampers, or HVAC equipment above T-bar type panel ceilings. Locate ceiling sticker on the ceiling grid closest to equipment. Label each sticker with the device located above the ceiling, i.e. VBR-33.

K. Identify ductwork with plastic tape duct markers. Identify service, flow direction and pressure when applicable, i.e. low pressure supply air, high pressure supply air. Install in clear view from floor and align with centerline of duct. Locations of identification not to exceed 15 feet from straight runs including risers and drops, more often in congested areas, at each side of penetration of structure or wall, and at each obstruction. When several ducts from different units are located in concealed congested areas, locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 23 05 53
SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions apply to this section.

1.2 DESCRIPTION OF WORK

A. This scope of services specifies the requirements and procedures for mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results. The test and balance work will be performed by the Owner’s personnel. It is the Contractor’s responsibility to assist as outlined below.

B. Test, adjust and balance the following mechanical systems which are shown in the construction documents.

1. Supply air systems, all pressure ranges, including variable volume and constant volume systems.
2. Return air systems.
3. Exhaust air systems.
4. Hydronic systems.
5. Verify temperature control system operation.

C. The contractor’s responsibilities are as follows:

1. Notify the Owner’s Representative twenty-one (21) days prior to the schedule date for balancing the system.
2. Schedule a two (2) week allowance for the testing and balancing firm to complete the testing and balancing work when scheduling completion of all work required of the Contractor by the contract documents.
3. Cooperate with the testing and balancing firm and shall make all necessary preparations for the TAB efforts.
4. Complete the following work prior to requesting the TAB effort.

   a. Clean and flush all piping systems.
   b. Leak test and make tight all piping systems.
   c. Fill all piping systems with clean water.
   d. Clean and seal all ductwork systems.
   e. Service and tag all equipment.
   f. Set and align all motors and drives.
   g. Start up and prove all equipment and systems.
h. Make preliminary settings on all control devices and have all systems operational.
  i. Operate all systems successfully for twenty-four (24) hours minimum.

5. Lubricate all motors and bearings.
6. Check fan belt tension.
7. Check fan rotation.
8. Patch insulation, ductwork and housing, using materials identical to those removed.
9. Seal ducts and piping, and test for and repair leaks.
10. Seal insulation to re-establish integrity of the vapor barrier.
11. Attend a coordination meeting prior to the balancing of the system and a coordination meeting following the balancing of the system.
12. Provide a complete set of as-built drawings prior to the TAB effort.
13. Provide craftsmen of the proper trade to work with the TAB firm to make adjustments and installation changes as required.
14. Change out fan sheaves when and if required by the TAB firm.
15. Dedicate the resources to accommodate all changes identified by the test and balance firm in a timely manner.
16. If a significant rebalance (Owner’s determination) of the HVAC system is required due to the Contractor’s failure to properly install and check out the HVAC system, the cost of rebalancing the system shall be borne by the Contractor.

1.3 PRE-BALANCING CONFERENCE

A. Prior to beginning of the testing, adjusting and balancing procedures, a conference with the Owner’s representative, Engineer and the Test and Balance Agency’s representative will be held. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting and balancing.

1.4 SEQUENCING AND SCHEDULING OF SERVICES

A. Test, adjust and balance the air conditioning systems during summer season and heating systems during winter season. This includes at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design conditions. Take final temperature readings during seasonal operation.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within +5 to 10 percent of design for supply systems, return and exhaust systems.
B. Air Outlets in Negatively Pressurized Spaces: Adjust total to within 0 to -5 percent of design to space.

C. Air Inlets in Negatively Pressurized Spaces: Adjust total to within 0 to +5 percent of design from space.

D. Air Outlets in Positively Pressurized Spaces: Adjust total to within 0 to +5 percent of design to space.

E. Air Inlets in Positively Pressurized Spaces: Adjust total to within 0 to -5 percent of design from space.

F. Air Outlets in Non-Pressurized Spaces: Adjust total to within 0 to +10 percent of design space.

G. Air Outlets in Non-Pressurized Spaces: Adjust total to within 0 to +10 percent of design space.

H. Hydronic Systems: Adjust to within +0 to 10 percent of design.

END OF SECTION 230593
SECTION 23 07 13 - DUCTWORK INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Ductwork insulation.

B. Insulation jackets.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Delivery, Storage, and Handling.

D. Quality assurance.

1. Materials: Flame spread/smoke developed rating of 25/50 or less.

E. Qualifications.

1. Applicator: Company specializing in performing the work of this section with minimum three years experience.

F. Environmental requirements.

1. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
2. Maintain temperature during and after installation as recommended by the manufacturer.

2. PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible blanket.

1. 'K' value: ASTM C518, 0.30 at 75 degrees F.

2. Maximum service temperature: 250 degrees F.

3. Maximum moisture absorption: less than 3 percent by volume.

4. Density: 1.5 lb/cu ft.
B. Vapor Barrier Jacket

C. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   1. Moisture vapor transmission: ASTM E96; 0.02 perm maximum.
   2. Secure with pressure sensitive tape.

D. Vapor Barrier Tape
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

E. Tie Wire: Annealed steel, 16 gage (1.5 mm).

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible blanket.
   1. 'K' value: ASTM C518, 0.23 at 75 degrees F.
   2. Maximum service temperature: 250 degrees F.
   3. Maximum moisture absorption: less than 3 percent by volume.

B. Vapor Barrier Jacket
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.02 perm.
   3. Secure with pressure sensitive tape.

C. Vapor Barrier Tape
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.3 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, sheet.
   1. 'K' ('ksi') Value: ASTM C177 or C518; 0.27 at 75 degrees F.
   2. Minimum Service Temperature: -40 degrees F.
   3. Maximum Service Temperature: 220 degrees F.
   4. Maximum Moisture Absorption: ASTM D209; 0.2 percent by volume.
   5. Moisture Vapor Transmission: ASTM E96; 0.08 perm-inches.
7. Maximum Smoke Developed: ASTM E84; 50.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS

A. Aluminum Jacket: ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Jacket: Aluminum construction, stucco embossed finish, 0.032” thick, with minimum 3-mil thick heat-bonded polyethylene and kraft paper vapor barrier.
2. Lagging Adhesive: Compatible with insulation and application.

3. EXECUTION

3.1 EXAMINATION

A. Verify that ductwork has been tested before applying insulation materials.
B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.
B. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
C. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

1. Extend insulation entirely down to neck of supply air diffusers and on top of diffusers. Provide continuous vapor barrier with diffuser insulation.
D. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
E. Secure insulation without vapor barrier with staples, tape, or wires.
F. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
G. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
H. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

I. Do not overtighten and/or compress flexible glass fiber duct insulation.

J. At duct access doors or other openings, insulation shall be properly framed and finished.

K. On all exterior ductwork, install metal jackets with a minimum 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Secure jacket with stainless steel bands 12” o.c. and at end joints.

L. Insulate the top of all supply air diffusers and the top/back of all supply air registers.

3.3 DUCTWORK INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>Ductwork Application:</th>
<th>Type:</th>
<th>Thickness:</th>
<th>Vapor Barrier Required (Y/N):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed rectangular outside air and supply air duct in mechanical rooms and shafts</td>
<td>Rigid</td>
<td>2”</td>
<td>Y</td>
</tr>
<tr>
<td>Round outside air and supply air duct in mechanical rooms</td>
<td>Flexible</td>
<td>2”</td>
<td>Y</td>
</tr>
<tr>
<td>All other rectangular and round return air, relief air, and exhaust air duct</td>
<td>None required unless shown on plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectangular and round return air, relief air, and exhaust air duct in other areas</td>
<td>None required unless shown on plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed/Concealed supply air duct</td>
<td>Flexible</td>
<td>2”</td>
<td>Y</td>
</tr>
<tr>
<td>Concealed round supply air duct</td>
<td>Flexible</td>
<td>2”</td>
<td>Y</td>
</tr>
</tbody>
</table>

Schedule Notes:

A. All ductwork in mechanical rooms shall be insulated as though it were “Exposed”.

END OF SECTION 23 07 13
SECTION 23 07 16 – HVAC EQUIPMENT INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Equipment insulation.

B. Covering.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Quality assurance.


D. Delivery, storage and handling.

E. Environmental requirements.

1. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

2. Maintain temperature during and after installation for minimum period of 24 hours.

2. PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible.

1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.

2. Maximum service temperature: 250 degrees F.

3. Maximum moisture absorption: 0.2 percent by volume.

4. Density: 2.0 lb/ cu ft.

B. Vapor Barrier Jacket

1. ASTM C921, kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.

D. Vapor Barrier Lap Adhesive: compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible.
   1. 'K' ('ksi') value: ASTM C335, 0.24 at 75 degrees F.
   2. Maximum service temperature: 450 degrees F.
   3. Maximum moisture absorption: 0.1 percent by volume.

B. Vapor Barrier Jacket
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.02 perm.
   3. Secure with self sealing longitudinal laps and butt strips.
   4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Vapor Barrier Lap Adhesive: Compatible with insulation.

D. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.3 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.
   1. 'K' ('ksi') value: ASTM C177 or C518; 0.27 at 75 degrees F.
   2. Minimum service temperature: -40 degrees F.
   3. Maximum service temperature: 220 degrees F.
   4. Maximum moisture absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
   5. Moisture vapor transmission: ASTM E96; 0.20 perm inches.
   7. Maximum smoke developed: ASTM E84; 50.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
2.4 CANVAS JACKET

A. Fabric: ASTM C921, 6 oz/sq yd, plain weave cotton treated with dilute fire retardant lagging adhesive.

B. Lagging Adhesive: Compatible with insulation.

3. EXECUTION

3.1 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Do not insulate factory insulated equipment.

C. On exposed equipment, locate insulation and cover seams in least visible locations.

D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

F. Insulated dual temperature equipment or cold equipment containing fluids below ambient temperature:
   1. Provide vapor barrier jackets, factory applied or field applied.
   2. Finish with glass cloth and vapor barrier adhesive.
   3. Insulate entire system.

G. For insulated equipment containing fluids above ambient temperature:

H. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
   1. Finish with glass cloth and adhesive.
   2. For hot equipment containing fluids do not insulate flanges and unions, but bevel and seal ends of insulation.
I. Inserts and Shields:

1. Application: equipment 1-1/2 inches diameter or larger.
2. Shields: galvanized steel between hangers and inserts.
3. Insert location: between support shield and equipment and under the finish jacket.
4. Insert configuration: minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

J. Finish insulation at supports, protrusions, and interruptions.

K. For equipment in mechanical equipment rooms or in finished spaces, finish with canvas jacket sized for finish covering.

L. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

M. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

3.3 TOLERANCE

A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.4 GLASS FIBER, FLEXIBLE INSULATION SCHEDULE

Heating Systems

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Thickness (inches):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air separators</td>
<td>2&quot;</td>
</tr>
</tbody>
</table>

3.5 GLASS FIBER, RIGID INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Thickness (inches):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air handling units air handling unit section</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>(if not factory insulated)</td>
<td></td>
</tr>
</tbody>
</table>

3.6 CELLULAR FOAM INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Thickness (inches):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling system suction diffusers and triple duty valves</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>Cooling systems flanged strainer bodies</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>Condensate drain pans</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>Cooling system pumps and tanks</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>Cooling system air separators</td>
<td>1-1/2&quot;</td>
</tr>
</tbody>
</table>
University of Missouri Health Care
AP Green Building Laboratory Consolidation
Columbia, Missouri

Contract Documents

MU Project #: CP190421
TCEP Project #: 624-157-18

END OF SECTION 23 07 16
SECTION 23 07 19 – HVAC PIPING INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.
   1. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84, NFPA 255, and UL 723.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Environmental requirements
   1. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
   2. Maintain temperature during and after installation for minimum period of 24 hours.

2. PRODUCTS

2.1 GLASS FIBER

A. Insulation: ASTM C547; rigid molded, noncombustible.

   1. 'k' ((btu*in)/(hr*ft²*deg F)) value : ASTM C335

<table>
<thead>
<tr>
<th>Temperature (degrees F)</th>
<th>Maximum 'k' value (btu<em>in)/(hr</em>ft²*deg F)</th>
</tr>
</thead>
</table>

HVAC PIPING INSULATION
HVAC PIPING INSULATION

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Insulation Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>0.23</td>
</tr>
<tr>
<td>100</td>
<td>0.24</td>
</tr>
<tr>
<td>150</td>
<td>0.25</td>
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<tr>
<td>200</td>
<td>0.28</td>
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<tr>
<td>300</td>
<td>0.34</td>
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<td>400</td>
<td>0.42</td>
</tr>
<tr>
<td>500</td>
<td>0.51</td>
</tr>
</tbody>
</table>

2. Minimum Service Temperature: 0 degrees F.
3. Maximum Service Temperature: 1000 degrees F.
4. Maximum Moisture Absorption: 0.2% by volume.

B. Vapor Barrier Jacket

1. ASTM C921, White kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture Vapor Transmission: ASTM E96; 0.02 perms.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Vapor Barrier Lap Adhesive: compatible with insulation. VOC Limit 50 g/L.

D. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool. VOC Limit 70 g/L (multipurpose construction adhesive).

E. Fibrous Glass Fabric: Cloth, untreated; 9 oz/sq yd weight with 1.0 lb/cu ft density blanket.

F. Indoor Vapor Barrier Finish: Vinyl emulsion type acrylic, compatible with insulation, white color. VOC Limit 50 g/L.

2.2 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. 'k' ((btu*in)/(hr*ft²*deg F)) value: ASTM C177 or C518; 0.22 to 0.28 at 60 degrees F.
2. Minimum Service Temperature: -20 degrees F.
3. Maximum Service Temperature: 180 degrees F.
4. Maximum Moisture Absorption: ASTM C209; 0.2 percent by volume.
5. Moisture Vapor Transmission: ASTM E96; 0.08 perm inches.
7. Maximum Smoke Developed: ASTM E84; 50.
9. Provide documentation indicating that product contains no urea formaldehyde.
10. Fittings: Pre-fabricated closed cell fittings of like material and thickness as adjacent pipe insulation.
11. In all exposed finished areas without jacketing, provide white insulation, otherwise use black.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. VOC Limit: 80 g/L.

2.3 INSULATION BLANKETS FOR STEAM AND CONDENSATE FLANGED VALVES AND EXPANSION JOINTS

A. Insulation: Tight-fitting, reusable insulation blanket consisting of high-density insulation (fiberglass, mineral wool, ceramic fiber) covered on outside with coated glass fabric having heavy adjustable straps with buckles. Inside of blanket shall be covered with fabric suitable to specified temperature of stainless steel square mesh woven wire cloth. Insulation shall be a minimum of 2" thick and shall be suitable for temperatures up to 500 Deg. F.

2.4 JACKETS

A. PVC Plastic

1. Jacket: ASTM C921, One piece molded type fitting covers and sheet material, white color.
   a. Minimum Service Temperature: 0 degrees F.
   b. Maximum Service Temperature: 150 degrees F.
   c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
   d. Maximum Flame Spread: ASTM E84; 25.
   e. Maximum Smoke Developed: ASTM E84; 50.
   f. Thickness: 20 mil.
   g. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

2. Covering Adhesive Mastic: Compatible with insulation. VOC Limit 50 g/L.


1. Thickness: 0.040 inch.
2. Finish: Smooth.
4. Fittings: PVC pre molded fittings.
5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.
3. **EXECUTION**

3.1 **EXAMINATION**

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 **INSTALLATION**

A. Install materials in accordance with manufacturer's instructions.

B. Painting of cellular foam insulation is not allowed.

C. On exposed piping, locate insulation and cover seams in least visible locations. For cellular foam insulation tape ALL visible seams with tape matching insulation color.

D. Fiberglass insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, flanges, unions, strainers, flexible connectors, and valves with molded insulation of like material and thickness as adjacent pipe. PVC or aluminum covers are required in all exposed locations as in mechanical rooms and finished areas.
3. Finish with glass cloth and vapor barrier adhesive.
4. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
5. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

E. Cellular foam insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

1. Insulate fittings, joints, flanges, unions, strainers, flexible connectors, and valves with molded insulation of like material and thickness as adjacent pipe. PVC or aluminum covers are required in all exposed locations as in mechanical rooms and finished areas.
2. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
3. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

F. Fiberglass insulated pipes conveying fluids above ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. PVC covers are required in all exposed locations.
3. Finish with glass cloth and adhesive.
4. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
5. For hot piping conveying fluids, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
6. For steam and condensate piping, insulate flanges and unions.

G. Inserts and Shields:

1. Refer to Section 23 05 29 for additional information.
2. Application: Piping 1 inch diameter or larger.
3. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
4. Insert Location: Between support shield and piping and under the finish jacket.
5. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
6. Insert Material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
7. Provide inserts and/or shields per manufacturer recommendations for cellular foam insulation applications in order to maintain continuous insulation throughout the pipe system. The removal of sections of cellular foam insulation to accommodate pipe supports is not acceptable. Manufacturer products specifically designed for supporting insulation and maintaining the integrity of the insulation system at pipe hanger locations, such Armaflex Armafix Insulation Pipe Hangers, are acceptable.

H. Finish insulation at supports, protrusions, and interruptions.

I. For pipe exposed in finished areas, finish with white PVC jacket and PVC fitting covers.

J. For piping exposed in mechanical rooms below 10 feet above finished floor, finish with aluminum jacket and aluminum fitting covers.

K. All valves in insulated systems shall have valve stem extensions. Insulation installer shall notify the contractor and Owner if valves without stem extensions are encountered. All valves without stem extensions in areas where stem extensions are required shall be replaced.

L. Install insulation blanket on steam and condensate valves.

M. Provide insulation clearance and access to valves and fittings in hangers and from structure and other equipment. Insulation shall be continuous through all hangers and supports. Refer to Section 23 07 19.

3.3 GLASS FIBER INSULATION SCHEDULE

A. Heating Systems

<table>
<thead>
<tr>
<th>PIPING SYSTEM</th>
<th>PIPE SIZE:</th>
<th>THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Water Supply and Return</td>
<td>1-1/4” &amp; smaller</td>
<td>1-1/2”</td>
</tr>
<tr>
<td>Heating Water Supply and Return</td>
<td>1-1/2” and larger</td>
<td>2”</td>
</tr>
</tbody>
</table>
### 3.4 CELLULAR FOAM INSULATION SCHEDULE

#### A. Cooling Systems

<table>
<thead>
<tr>
<th>PIPING SYSTEM</th>
<th>PIPE SIZE:</th>
<th>THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Supply and Return</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Process Chilled Water Supply and Return</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Cold Condensate Drains</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>All sizes</td>
<td>1-1/2&quot;</td>
</tr>
</tbody>
</table>

#### B. Heat Recovery

<table>
<thead>
<tr>
<th>PIPING SYSTEM</th>
<th>PIPE SIZE:</th>
<th>THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Recovery Water</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Heat Recovery Coil Return Bends</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Heat Recovery Coil Drains</td>
<td>All sizes</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

END OF SECTION 23 07 19
PART 1 - GENERAL

1.1. DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process, which are being directed by the CxA.

B. The systems to be commissioned are listed in Section 01 91 00 Part 1.10.

C. Commissioning requires the participation of Division 23 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 09 00. Division 23 shall be familiar with all parts of Section 01 09 00 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2. RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment only):

   Construction and Acceptance Phases

   1. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Cx process.

   2. Contractors shall provide the CxA with normal cut sheets and shop drawing submittals of commissioned equipment.

   3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.

      a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

      b. The Commissioning Agent may request further documentation necessary for the commissioning process.

      c. This data request may be made prior to normal submittals.

   4. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

   5. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

   6. Provide assistance to the CxA in preparing the specific functional performance test procedures as specified in Section 23 08 00. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

   7. Develop a full start-up and initial checkout plan using manufacturer’s start-up procedures and the prefunctional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup. Refer to Section 01 91 00 for further details on start-up plan preparation.

   8. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
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9. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

10. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.

11. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

12. Provide skilled technicians to perform functional performance testing under the direction of the CxA for specified equipment in Section 01 91 00. Assist the CxA in interpreting the monitoring data, as necessary.

13. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, CM and A/E and retest the equipment.

14. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

15. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builds for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

16. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the HVAC mechanical contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment, except for the building automation control system.

2. Assist and cooperate with the TAB contractor and CxA by:
   a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
   b. Including cost of sheaves and belts that may be required by TAB.
   c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Provide an approved plug.
   d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor which is an input point to the control system.

4. List and clearly identify on the as-built drawings the locations of all air-flow stations.

5. Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.

6. Notify the CM or CxA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the CM...
or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and at the CxA has the scheduling information needed to efficiently execute the commissioning process.

C. Controls Contractor. The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. **Sequences of Operation Submittals.** The Controls Contractor’s submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
   a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
   b. All interactions and interlocks with other systems.
   c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
   d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers’ stock sequences may be included but will generally require additional narrative).
   e. Start-up sequences.
   f. Warm-up mode sequences.
   g. Normal operating mode sequences.
   h. Unoccupied mode sequences.
   i. Shutdown sequences.
   j. Capacity control sequences and equipment staging.
   k. Temperature and pressure control: setbacks, setups, resets, etc.
   l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, demand controlled ventilation, etc.
   m. Effects of power or equipment failure with all standby component functions.
   n. Sequences for all alarms and emergency shutdowns.
   o. Seasonal operational differences and recommendations.
   p. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
   q. Schedules, if known.
   r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. **Control Drawings Submittal**
   a. The control drawings shall have a key to all abbreviations.
   b. The control drawings shall contain graphic schematic depictions of the systems and each component.
   c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
   d. Provide a full points list with at least the following included for each point:
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1) Controlled system
2) Point abbreviation
3) Point description
4) Display unit
5) Control point or setpoint (Yes / No)
6) Monitoring point (Yes / No)
7) Intermediate point (Yes / No)
8) Calculated point (Yes / No)

**Key:**
- **Point Description:** DB temp, airflow, etc.
- **Control or Setpoint:** Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
- **Intermediate Point:** Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
- **Monitoring Point:** Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
- **Calculated Point:** “Virtual” point generated from calculations of other point values.

The Controls Contractor shall keep the CxA informed of all changes to this list during programming and setup.

3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

4. Assist and cooperate with the TAB contractor in the following manner:
   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required prefuctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CxA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB or provide sufficient training for TAB to operate the system without assistance.

5. Assist and cooperate with the CxA in the following manner:
   a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system as specified for the controls contractor. Assist in the functional testing of all equipment specified. Provide two-way radios during the testing as necessary.
   b. Execute all control system trend logs specified.

6. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 09 00. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
   b. List of devices.
c. Step-by-step procedures for testing each controller after installation, including:
   1) Process of verifying proper hardware and wiring installation.
   2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
   3) Process of performing operational checks of each controlled component.
   4) Plan and process for calibrating valve and damper actuators and all sensors.
   5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.

e. A description of the instrumentation required for testing.

f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CxA and TAB contractor for this determination.

7. Provide a signed and dated certification to the CxA and CM upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

8. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified in Section Direct Digital Control Systems.

9. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

D. TAB Contractor. The duties of the TAB contractor, in addition to those listed in (A) are:

1. Six weeks prior to starting TAB, submit to the CM the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician’s qualifications for this project.

2. Submit the outline of the TAB plan and approach for each system and component to the CxA, CM and the controls contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.

3. The submitted plan will include:
   a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
   b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.
   c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
   d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
   e. Final test report forms to be used.
   f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc.
Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.

g. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.

h. Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).

i. The identification and types of measurement instruments to be used and their most recent calibration date.

j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.

k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.

l. Details of whether and how minimum outside air CFM will be verified and set and for what level (total building, zone, etc.).

m. Details of how building static and exhaust fan / relief damper capacity will be checked.

n. Proposed selection points for sound measurements and sound measurement methods.

o. Details of methods for making any specified coil or other system plant capacity measurements.

p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.

q. Details regarding specified deferred or seasonal TAB work.

r. Details of any specified false loading of systems to complete TAB work.

s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.

t. Details of any required interstitial cavity differential pressure measurements and calculations.

u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

v. Plan for formal progress reports (scope and frequency).

w. Plan for formal deficiency reports (scope, frequency and distribution).

4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CxA and CM at least twice a week.

5. Communicate in writing to the controls contractor all setpoint and parameter changes made, or problems and discrepancies identified, during TAB which affect the control system setup and operation.

6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.

7. Provide the CxA with any requested data, gathered, but not shown on the draft reports.

8. Provide a final TAB report for the CxA with details, as in the draft.

9. Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 01 91 00 Part 3
E. Mechanical Designer/Engineer. Refer to Section 01 91 00 for the responsibilities of the mechanical designer/engineer.

1.3. RELATED WORK
A. Refer to Section 01 91 00 Part 1.8 for a listing of all sections where commissioning requirements are found.
B. Refer to Section 01 91 00 Part 1.11 for systems to be commissioned and Section 01 91 000 Part 3.6 for functional testing requirements.

PART 2 - PRODUCTS
A. TEST EQUIPMENT
B. Division 23 shall provide all test equipment necessary to fulfill the testing requirements of this Division.
C. Refer to Section 01 91 00 Part 2.1 for additional Division 23 requirements.

PART 3 - EXECUTION
3.1. SUBMITTALS
A. Division 23 shall provide submittal documentation relative to commissioning as required in this Section Part 1, Section 01 33 00 Construction Submittal Procedures and Section 01 91 00 Part 3.3.

3.2. STARTUP
A. The HVAC mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00 Part 3.4. Division 23 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3. TAB
A. Refer to the TAB responsibilities in Part 1.2 above.

3.4. FUNCTIONAL PERFORMANCE TESTS
A. Refer to Section 01 91 00 Part 1.11 for a list of systems to be commissioned and to Part 3.6 for a description of the process.

3.5. TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS
A. Refer to Section 01 91 00 Part 3.4 for specific details on non-conformance issues relating to prefunctional checklists and tests.
B. Refer to Section 01 91 00 Part 3.7 for issues relating to functional performance tests.

3.6. OPERATION AND MAINTENANCE (O&M) MANUALS
A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.
B. Division 23 shall compile and prepare documentation for all equipment and systems covered in Division 23 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section prior to the training of owner personnel.
C. The CxA shall receive a copy of the O&M manuals for review.
D. **Special Control System O&M Manual Requirements.** In addition to documentation that may be specified elsewhere, the controls contractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs.

1. Three copies of the controls training manuals in a separate manual from the O&M manuals.

2. Operation and Maintenance Manuals containing:
   a. Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
   b. Full as-built set of control drawings (refer to Submittal section above for details).
   c. Full as-built sequence of operations for each piece of equipment.
   d. Full points list. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:
      1) Building
      2) Floor
      3) Room number
      4) Room name
      5) Air handler unit ID
      6) Reference drawing number
      7) Air terminal unit tag ID
      8) Heating and/or cooling valve tag ID
      9) Minimum cfm
      10) Maximum cfm
   e. Full print out of all schedules and set points after testing and acceptance of the system.
   f. Full as-built print out of software program.
   g. Electronic copy on disk of the entire program for this facility.
   h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
   i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
   j. Control equipment component submittals, parts lists, etc.
   k. Warranty requirements.
   l. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

3. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
   a. Sequences of operation
   b. Control drawings
   c. Points lists
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d. Controller / module data

e. Thermostats and timers

f. Sensors and DP switches
g. Valves and valve actuators

h. Dampers and damper actuators

i. Program setups (software program printouts)

4. Field checkout sheets and trend logs should be provided to the CxA for inclusion in the Commissioning Record Book.

E. Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the Specifications:

1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.

2. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

F. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the A/E and by the CxA. Refer to Section 01 91 00 Part 3.8 for details.

3.7. TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 Part 3.9 for additional details.

B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 00 Part 3.9 for additional details.

C. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00 Part 3.9.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, air conditioning units, air handling units, fans, terminal units, controls and air quality treatment systems, etc.

3. Training shall start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
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8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. The format and training agenda in *The HVAC Commissioning Process, ASHRAE Guideline 1-1989R*, 1996 is recommended.
   i. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

D. Controls Contractor. The controls contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan four weeks before the planned training according to the outline described in Section 01 91 00 Part 3.9.

2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA. Copies of audiovisuals shall be delivered to the Owner.

4. The trainings will be tailored to the needs and skill-level of the trainees.

5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

8. There shall be three training sessions (Times listed here are minimums. Control contractor to confirm actual training time required and confirm with CxA and Owner.):

   a. **Training I. Control System.** The first training shall consist of 4 hours of actual training. This training may be held on-site or in the supplier’s facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.

   b. **Training II. Building Systems.** The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
      1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
      2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
      3) All trending and monitoring features (values, change of state, totalization, etc.) including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
      4) Every screen shall be completely discussed, allowing time for questions.
      5) Use of keypad or plug-in laptop computer at the zone level.
      6) Use of remote access to the system via phone lines or networks.
      7) Setting up and changing an air terminal unit controller.
      8) Graphics generation
      9) Point database entry and modifications
      10) Understanding DDC field panel operating programming (when applicable)

   c. **Training III.** The third training will be conducted on-site six months after occupancy and consist of 4 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

E. **TAB** The TAB contractor shall have the following training responsibilities (Time listed here is minimum time required. TAB Contractor to confirm actual training time required and confirm with CxA and Owner.):

   1. TAB shall meet for 2 hours with facility staff after completion of TAB and instruct them on the following:
      a. Go over the final TAB report, explaining the layout and meanings of each data type.
      b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
      c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
      d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
      e. Other salient information that may be useful for facility operations, relative to TAB.
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3.8. DEFERRED TESTING
   A. Refer to Section 01 91 00 Part 3.10 for requirements of deferred testing.

3.9. WRITTEN WORK PRODUCTS
   A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 Part 3.11 and the filled-out start-up, initial checkout and prefunctional checklists.

END OF SECTION 23 08 00
SECTION 23 09 00 – DIGITAL CONTROL EQUIPMENT

1. GENERAL

1.1 SUMMARY

A. University of Missouri Controls Specification.

B. This section contains requirements for pneumatic, electric and digital control systems as indicated on the contract drawings.

C. Contractor is responsible for providing, installing and connecting all sensors, pneumatic actuators, control valves, control dampers, electrical components and all interconnecting pneumatic tubing and electrical wiring between these devices and up to the Direct Digital Controller (DDC).

D. DDC systems consist of Johnson Controls METASYS controllers. Contractor shall install owner provided control enclosures. Owner will provide and install controllers. After all equipment has been installed, wired and piped, Owner will be responsible for all termination connections at the DDC controller’s and for checking, testing, programming and start-up of the control system. Contractor must be on site at start-up to make any necessary hardware adjustments as required.

E. Once each mechanical system is completely operational under the new control system, contractor shall make any final connections and adjustments. For controls renovation jobs, contractor shall remove all unused sensors, operators, panels, wiring, tubing, conduit, etc. Owner shall have the option of retaining any removed pneumatic controls.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the contract, including General and supplementary conditions and Division 1 Specification sections, apply to work of this section.

B. Points List included on the plans or in the specifications.

C. Other appropriate Division 23 specifications.

D. Other appropriate Division 26 specifications.

1.3 SUBMITTALS
A. Shop Drawings: Submit shop drawings for each control system, containing the following information:

B. Product data for each damper, valve, and control device.

C. Schematic flow diagrams of system showing fans, pumps, coils, dampers, valves, and control devices.

D. Label each control device with setting or adjustable range of control.

E. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Provide details of faces on control panels, including controls, instruments, and labeling.

G. Include written description of sequence of operation.

H. Provide wiring diagrams of contractor provided interface and I/O panels.

I. Provide field routing of proposed network bus diagram listing all devices on bus.

1.4 PROJECT RECORD DOCUMENTS

A. See Section 230500.

1.5 OPERATION AND MAINTENANCE DATA

A. See Section 230500.

B. Maintenance Data: Submit maintenance instructions and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.6 QUALITY ASSURANCE

A. Contractor's Qualifications:

1. Contractor shall be regularly engaged in the installation of digital control systems and equipment, of types and sizes required. Contractor shall have a minimum of five years experience installing digital control systems. Contractor shall supply sufficient and competent supervision and personnel throughout the project in accordance with General Conditions section 3.4.1 and 3.4.4.
1.7 Codes and Standards:

A. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.

B. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.

C. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

D. NFPA Compliance: Comply with NFPA 70 "National Electric Code".

1.8 WARRANTY

A. Correct all defective work within a period of one (1) year after substantial completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 230500.

2. PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Air Piping:

1. Copper Tubing: Seamless copper tubing, Type M or L, ASTM B 88; wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment.

2. Flex Tubing: Virgin Polyethylene non-metallic tubing, ASTM D 2737, with flame-retardant harness for multiple tubing. Use compression or push-on polyethylene fittings. Tubing used above suspended ceilings to be plenum rated per NFPA 90A. See section 3.1.b for locations where flex tubing can be used.

3. Copper to polyethylene connections shall be compression barbed fittings or solder barbed fittings.

B. Conduit and Raceway:

1. Electrical Metallic Tubing: EMT and fittings shall conform to ANSI C80.3.

2. Surface Metal Raceway and Fittings: Wiremold 500, Ivory, or approved equal.

3. Flexible Metal Conduit: Indoors, per National Electric Code for connection to moving or vibrating equipment.
4. Liquidtight Flexible Conduit: Outdoors, per National Electric Code for connection to moving or vibrating equipment.

C. Control Valves: Provide factory fabricated pneumatic or electric control valves of type, body material, and pressure class as indicated on the drawings. Butterfly style control valves are not acceptable except for two position applications. Equip control valves with heavy-duty actuators, with proper shutoff rating for each individual application.

1. Steam and Hot Water
   a. Manufacturer: Do not allow KMC valves and actuators.
   b. Water Service Valves: Equal percentage characteristics.
   c. Steam Service Valves: Equal percentage characteristics.
   d. Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.
   e. Valve Trim and Stems: Polished stainless steel.
   g. Control valves should have a minimum 100 psi close-off rating for chilled water applications.

2. Hydronic Chilled Water and Pipe Kits (small heating coils)
   a. At minimum, chilled water and pipe kit control valves (small heating coils) shall be pressure independent. High performing energy monitoring control valves may be considered depending on the project. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow.
   b. The valve bodies shall be of cast iron, steel or bronze and rated for 150 PSI working pressure. All internal parts shall be stainless steel, steel, Teflon, brass, or bronze.
   c. DeltaP Valves manufactured by Flow Control Industries, Belimo, Danfoss Series, or approved equal.
   d. The valves shall have pressure taps across the valve for measuring the pressure drop across the valve. The pressure taps shall have ½-inch extensions for accessibility.
   e. Control valves shall be installed with unions or flanges as necessary for easy removal and replacement.
   f. Valve Tag shall include the model number, AHU being served, design flow, and maximum flow for that valve.
   g. The control valves shall be delivered preset to the scheduled design flow and should be capable of reaching 110% of the design flow to allow for field adjustment for capacity changes.

D. Control Dampers: Ruskin CD-50 or approved equal.
   1. Provide dampers with parallel blades for 2- position control.
2. Provide opposed blades for modulating control.
3. Dampers shall be low leakage design with blade and edge seals.
4. Provide multiple sections and operators as required by opening size and sequence of operations, as indicated on the contract drawings.

E. Electric Actuators: Johnson Controls, Bray, Belimo, TAC or approved equal. KMC actuators are not approved. Size electric actuators to operate their appropriate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. If mixed air AHU has return air, exhaust air and outside air dampers that are not mechanically linked then static safety switch must be installed and wired to safety circuit. Spring return actuators should be provided on heat exchanger control valves or dampers or as specified on the drawings. Control signal shall be 0 to 10 VDC unless otherwise specified on drawings. Actuators with integral damper end switch are acceptable. For VAV reheat valves, actuators shall have a manual override capability to aid in system flushing, startup, and balancing.

F. Air and Hot Water Electronic Temperature Sensors:
1. All electronic temperature sensors shall be compatible with Johnson METASYS systems.
2. Sensors shall be 1,000 ohm platinum, resistance temperature detectors (RTDs) with two wire connections. Duct mounted sensors shall be averaging type. Contractor may install probe type when field conditions prohibit averaging type, but must receive permission from Owner's Representative.
3. Coordinate thermowell manufacturer with RTD manufacturer. Thermowells that are installed by the contractor, but are to have the RTD installed by owner, must be Johnson Controls Inc. series WZ-1000.

G. Electronic Temperature Sensors and Transmitters:
   a) General: The RTD/Temperature Transmitter-Thermowell assembly shall come as a complete assembly from a single manufacturer. The Assembly shall be suitable for use in the accurate measurement of Chilled/Tower/Hot Water and steam temperatures in a mechanical room environment.
   b) Calibration: Each RTD must be match calibrated to the Transmitter via NIST traceable calibration standards. Results are to be programmed into the transmitter. Results are to be presented on report as after condition at the specified calibration points. Assembly shall not be approved for installation until Owner has received all factory calibration reports.
   c) RTD:
      (1) RTD type: 2-wire or 3-wire 100 ohm platinum class A
      (2) Outside Diameter: 0.25 inch
      (3) Tolerance: +/- 0.06% Type A
      (4) Stability: +/- 0.1 % over one year.
      (5) TCR: 0.00385 (ohm/ohm/°C).
      (6) RTD shall be tip sensitive.
      (7) Resistance vs. Temperature table for the RTD must be provided to the Owner.
   d) Transmitter:
(1) Transmitter shall be match calibrated to the RTD and assembled as a matched pair.

(2) Type: 2 wire (loop powered)

(3) Input: 2 or 3 wire 100 ohm platinum class A or class B RTD

(4) Output: Output shall be a 4-20 mA signal linear to temperature

(5) Calibrated Span:
   (a) Chilled Water: 30°F to 130°F.
   (b) Tower Water: 30°F to 130°F.
   (c) Hot Water: 100°F to 250°F.
   (d) Steam: 150°F to 450°F

(6) Calibration Accuracy, including total of all errors, of the Transmitter & RTD matched pair over the entire span shall be within +/- 0.2% of the calibrated span or +/- 0.18°F, whichever is greater.

(7) Supply Voltage: 24 VDC.

(8) Ambient Operating Temp.: 32 to 122°F

(9) Epoxy potted for moisture resistance.

(10) Mounting: Transmitter shall be mounted in the RTD connection head.

e) Thermowell
   (1) Thermowell shall be suitable for immersion in chilled/hot water and steam.
   (2) Thermowell shall be reduced tip.
   (3) Thermowell shall be one piece stainless steel machined from solid bar stock.
   (4) Thermowell shall have 1/2" NPT process connection to pipe thread-let.
   (5) Thermowell Insertion depth shall be ½ the inside pipe diameter but not to exceed 10".

f) Assembly:
   (1) Assembly configuration: Spring loaded RTD with thermowell-double ended hex-connection head.
   (2) Connection head shall be cast aluminum with chain connecting cap to body, have 1/2" NPT process and 3/4" NPT conduit connections, and a sealing gasket between cap and body.

g) RTD/Temperature Transmitter/Thermowell assembly shall be the following or approved equal:
   (1) Manufacturer: Pyromation, Inc.
   (2) Chilled Water: RAF185L-S4C[length code]08-SL-8HN31, TT440-385U-S(30-130)F with calibration SMC(40,60)F
   (3) Tower Water: RAF185L-S4C[length code]08-SL-8HN31, TT440-385U-S(5130)F with calibration SMC(55,85)F
   (4) Hot Water: RAF185L-S4C[length code]08T2-SL-8HN31, TT440-385U-S(100-250)F with calibration SMC(140,180)F
   (5) Steam: RAT185H-S4C[length code]08T2-SL-8HN31, TT440-385U-S(150-450)F with calibration SMC(300,350)F

H. Occupant Override: Provide wall mounted occupant override button in locations shown on drawings.
I. Low Limit Controllers: Provide unit-mounted low limit controllers, of rod-and-tube type, with an adjustable set point and a manual reset. Capillary shall be of adequate length to horizontally traverse face of cooling coil every 12". Multiple low limit controllers may be required for large coils. Controller shall have an extra set of contactors for connection to control panel for alarm status. Locate the thermostat case and bellows where the ambient temperature is always warmer than the set point.
   1. Freez Stats: Johnson Controls model A70HA-1 or approved equal.

J. Humidistats: Humidistats must be contamination resistant, capable of ±2% RH accuracy, have field adjustable calibration and provide a linear proportional signal.
   1. HD20K-T91 or equivalent.

K. Humidity High Limit
   1. Multi-function device that can function as a high limit or proportional override humidity controller, as stand-alone proportional controller, or a stand-alone two-position controller.
      a) Johnson Controls TRUERH HL-67N5-8N00P or approved equal.

L. Carbon Dioxide Sensor:
   1. Wall Mount: ACI Model ESENSE-R.
   2. Duct Mount: ACI Model ESENSE-D.

M. Fan/Pump Status: Status points for fan or pump motors with a VFD must be connected to the terminal strip of the VFD for status indication.
   Current switches: Current switches are required for fan and pump statuses that are not connected to a VFD. The switches must have an adjustable trip setpoint with LED indication and be capable of detecting broken belts or couplings. Units shall be powered by monitored line, UL listed and CE certified, and have a five year warranty.
   1. Kele, Hawkeye or approved equal.

N. Relays Used for Fan and Pump Start/Stop: Must have LED indication and be mounted externally of starter enclosure or VFD.
   1. Kele, RIBU1C or approved equal.

O. Power Supply Used to Provide Power to Contractor-Provided Control Devices: Shall have adjustable DC output, screw terminals, overload protection and 24 VAC and 24 VDC output.
   1. Kele, DCPA-1.2 or approved equal.

P. Pressure Differential Switch:
   1. Fans: NECC model DP222 or approved equal.

Q. Differential Pressure Transmitter: Provide units with linear analog 4-20mA output proportional to differential pressure, compatible with the Johnson METASYS Systems.
   1. Water: Units shall be wet/wet differential pressure capable of a bi-directional pressure range of +/- 50 psid. Accuracy shall be +/- 0.25% full scale with a compensated temperature range of 30 to 150 deg F and a maximum working pressure of 250 psig.
   2. Install transmitter in a pre-manufactured assembly with shut off valves, vent valves and a bypass valve.
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a) Setra model 230 with Kele model 3-VLV, three valve manifold or approved equal.

3. Air: Units shall be capable of measuring a differential pressure of 0 to 5 in. WC. Accuracy shall be +/- 1.0% full scale with a compensated temperature range of 40 to 149 deg F and a maximum working pressure of 250 psig.
   a) Setra model 267, or approved equal.
   b) Shall be installed in control panel and piped 2/3 down the duct unless shown otherwise or approved by owners representative.

**R. Building Static Pressure:** Transducer shall utilize a ceramic capacitive sensing element to provide a stable linear output over the specified range of building static pressure. Transducer shall be housed in a wall-mounted enclosure with LCD display. Transducer shall have the following capabilities:

1. Input Power: 24 VAC
2. Output: 0-10 VDC
3. Pressure Range: -0.25 to +0.25 inches w.g.
4. Display: 3-1/2 digit LCD, displaying pressure in inches w.g.
5. Accuracy: +/- 1.0% combined linearity and hysteresis
6. Temperature effect: 0.05% / deg C
7. Zero drift (1 year): 2.0% max
8. Zero adjust: Push-button auto-zero and digital input
9. Operating Environment: 0 to 140 deg F, 90% RH (non-condensing)
10. Fittings: Brass barbs, 1/8” O.D.
11. Enclosure: High-impact ABS plastic
12. Outside Air Sensor Pickup Port: UV stabilized thermoplastic or aluminum “can” enclosure to shield outdoor pressure sensing tube from wind effects. BAPI ZPS-ACC10-rooftop mount, wall mount, or equivalent.
13. Transducer shall be Veris Industries Model PXPLX01S, equivalent from Setra, or approved equal.

**S. High Static Pressure Limit Switch:** Provide pressure high limit switch to open contact in fan circuit to shut down the supply fan when the inlet static pressure rises above the set point. Provide with an adjustable set point, a manual reset button, 2 SPST (normally closed) contacts, and ¼” compression fittings.

1. Kele model AFS-460-DDS, or approved equal.

**T. Airflow/temperature measurement devices:**

1. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
2. The measurement device shall consist of one or more sensor probe assemblies and a single, remotely mounted, microprocessor-based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. The airflow and temperature readings calculated for each sensor housing shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable.
3. All Sensor Probe Assemblies
   a) Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
b) Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use “chip” or diode case type thermistors are unacceptable. Devices that do not have 2 thermistors in each sensor housing are not acceptable.

c) Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/-2% of reading over the entire operating airflow range. Each sensor housing shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
   (1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

d) The operating temperature range for the sensor probe assembly shall be -20° F to 160 F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).

e) Each temperature sensor shall be calibrated at a minimum of 3 temperatures and have an accuracy of +/-0.15° F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

f) Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g) Each sensor assembly shall not require matching to the transmitter in the field.

h) A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

4. Duct and Plenum Sensor Probe Assemblies

a) Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly. Thermistor probes shall be mounted in sensor housings using a waterproof marine grade epoxy resin. All wires within the aluminum tube shall be Kynar coated.

b) The number of sensor housings provided for each location shall be as follows:
   (1) Area (sq.ft.)   Sensors
       <2             4
       2 to <4        6
       4 to <8        8
       8 to <16       12
       >=16           16

c) Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
   (1) Insertion mounted through the side or top of the duct.
   (2) Internally mounted inside the duct or plenum.
   (3) Standoff mounted inside the plenum.

d) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Duct mounted Vortex Shedding Assemblies

a) Airflow measuring devices of the vortex shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume, shall be provided where indicated. Airflow
measuring devices shall be of the insertion type, or built into airflow control valves, as required, with the capability of measuring velocity over the full range of 350 to 7000 FPM. Devices shall consist of multiple velocity sensors, supported on insertion probe bars. Tek-Air or approved equal

6. Fan Inlet Sensor Probe Assemblies
   a) Sensor housings shall be mounted on 304 stainless steel blocks.
   b) Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
   c) Mounting feet shall be constructed of 304 stainless steel.
   d) The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

7. Transmitters
   a) The transmitter shall have a 16 character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics. Configuration settings and diagnostics shall be accessed through a pushbutton interface on the main circuit board. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.
   b) The transmitter shall be capable of independently monitoring and averaging up to 16 individual airflow and temperature readings. The transmitter shall be capable of displaying the airflow and temperature readings of individual sensors on the LCD display.
   c) The transmitter shall have a power switch and operate on 24 VAC (isolation not required). The transmitter shall use a switching power supply fused and protected from transients and power surges.
   d) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
   e) The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.
   f) The transmitter shall be capable of communicating with the host controls using one of the following interface options:
      (1) Linear analog output signal: Field selectable, fuse protected and isolated, 0-10 VDC and 4-20mA (4-wire).
      (2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson Controls N2 Bus.
      (3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-TCP and TCP/IP.
      (4) LonWorks Free Topology.
   g) The transmitter shall have an infra-red interface capable of downloading individual sensor airflow and temperature data or uploading transmitter configuration data to a handheld PDA (Palm or Microsoft Pocket PC operating systems).

8. The measuring device shall be UL listed as an entire assembly.

9. The manufacturer’s authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer’s placement requirements.

10. Manufacturer
    a) Primary flow elements, sensors, meters and transducers shall be EBTRON, Inc. Model GTx116-P and GTx116-F or approved equal.
U. Electrical Requirements: Provide electric-pneumatic switches, electrical devices, and relays that are UL-listed and of type which meet current and voltage characteristics of the project. All devices shall be of industrial/commercial grade or better. Residential types will be rejected.

1. EP Switches: Landis & Gyr Powers, Inc. Series 265 - Junction Box Type or approved equal.
2. Relays: Relays shall have an LED status indicator, voltage transient suppression, Closed-Open-Auto switch, plastic enclosure, and color coded wires. Kele model RIBU1C or approved equal.

3. EXECUTION

3.1 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details shown on drawings.

B. Control Air Piping:
   1. All control air piping shall be copper. Exception: Flexible Tubing may be used for a maximum of two (2) feet at connections to equipment [except for steam control valves] and inside control cabinets.
   2. Provide copper tubing with a maximum unsupported length of 3'-0".
   3. Pressure Test control air piping at 30 psi for 24 hours. Test fails if more than 5 PSI loss occurs.
   4. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
   5. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system.
   6. All control tubing at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel.
   7. Provide pressure gages on each output device.
   8. Paint all exposed control tubing to match existing.

C. Raceway: Raceway is to be installed in accordance with the National Electric Code. Use of flexible metal conduit or liquidtight flexible conduit is limited to 36" to connect from EMT to devices subject to movement. Flexible raceway is not to be used to compensate for misalignment of raceway during installation.

D. Control Wiring: Install control wiring in raceway, without splices between terminal points, color-coded. Install in a neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.
   1. Install circuits over 25-volt with color-coded No. 12 stranded wire.
   2. Install electronic circuits and circuits under 25-volts with color-coded No. 18 stranded twisted shielded pair type conductor.
   3. N2 communications bus wire shall be 18 AWG, plenum rated, stranded twisted shielded,
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3 conductor, with blue outer casing, described as 18-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.

4. FC communications bus wire shall be 22 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, described as 22-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.

5. All control wiring at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel. Label all control wires per bid documents.

E. All low voltage electrical wiring shall be run as follows:
   1. Route electrical wiring in concealed spaces and mechanical rooms whenever possible.
   2. Provide EMT conduit and fittings in mechanical rooms and where indicated on drawings.
   3. Low voltage electrical wiring routed above acoustical ceiling is not required to be in conduit, but wire must be plenum rated and properly supported to building structure.
   4. Provide surface raceway, fittings and boxes in finished areas where wiring cannot be run in concealed spaces. Route on ceiling or along walls as close to ceiling as possible. Run raceway parallel to walls. Diagonal runs are not permitted. Paint raceway and fittings to match existing conditions. Patch/repair/paint any exposed wall penetrations to match existing conditions.

F. All devices shall be mounted appropriately for the intended service and location.
   1. Adjustable thermostats shall be provided with base and covers in occupied areas and mounted 48" above finished floor to the top of the device. Tubing and/or wiring shall be concealed within the wall up to the ceiling where ever possible. Surface raceway may only be used with approval of Owners Representative. Wall mounted sensors such as CO2, RH, and non-adjustable temperature sensors shall be mounted 54" above finished floor. Duct mounted sensors shall be provided with mounting brackets to accommodate insulation. Mounting clips for capillary tubes for averaging sensors are required.
   2. All control devices shall be tagged and labeled for future identification and servicing of control system.
   3. Preheat and mixed air discharge sensors must be of adequate length and installed with capillary tube horizontally traversing face of coil, covering entire coil every 24 inches bottom to top.
   4. All field devices must be accessible or access panels must be installed.

G. Install maneghelic pressure gage across each air handling unit filter bank. If the air handling unit has a prefilter and a final filter, two maneghelic pressure gages are required.

3.02 ADJUSTING AND START-UP

H. Start-Up: Temporary control of Air Handling Units shall be allowed only if approved by the owner’s representative to protect finishes, etc., AHUs may be run using caution with temporary controls installed by contractor early in the startup process. All safeties including a smoke detector for shut down must be operational. Some means of discharge air control shall be utilized and provided by the contractor such as a temporary temperature sensor and
controller located and installed by the Contractor.

1. The start-up, testing, and adjusting of pneumatic and digital control systems will be conducted by owner. Once all items are completed by the Contractor for each system, Contractor shall allow time in the construction schedule for owner to complete commissioning of controls before project substantial completion. This task should be included in the original schedule and updated to include the allotted time necessary to complete it. As a minimum, the following items are required to be completed by the Contractor for Owner to begin controls commissioning.

   1. Process Control Network
      a) The control boards and enclosures need to be installed in the mechanical rooms.
      b) The fiber optic conduit and box for the process control network needs to be installed. Once in place, Owner needs to be contacted so the length of the owner provided fiber cable can be determined and ordered, if required. Coordinate with Owner to schedule the pull in and termination of the fiber cable. Power should be in place at that time. (Fiber for the process control network is required to allow metering of utilities prior to turn on.)

   2. Heating System
      a) Pumps, heat exchangers, steam pressure reducing station, piping, control valves, steam and/or hot water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The house keeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, steam regulators set to required pressure, condensate pumps operational, heating system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

   3. Cooling System
      a) Pumps, heat exchangers, piping, control valves, chilled water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The house keeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, cooling system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

   4. VAVs-First Pass
      a) Power, (FC or N2 bus), and control wire installed before owner can make first commissioning pass. First pass includes installation of VAV controller, termination of power, control and network communication wiring.

   5. Air Handlers
      a) Prior to owner commissioning, at a minimum, the following items shall be complete: Power wiring, motor rotation check, fire/smoke dampers open, control wiring including all safeties, IO cabinet, air handler cleaned, and filters installed as required. To protect the systems from dirt, outside air with no return will be used until the building is clean enough for return air operation.

   6. VAVs-Second Pass
      a) After the air handlers are running and under static pressure control and the heating water system is operating, a second pass can be made on the VAVs to download the control program and commission controllers to verify the VAV dampers, thermostat, and reheat control valves are working properly.

   7. Exhaust and Energy Recovery Systems
8. Lab Air Controls
   a) Lab Air Controls vendor will have the same requirements as stated above for VAVs.

9. Some balance work can be done alongside the control work as long as areas are mostly complete and all diffusers are in place.

3.3 CLOSEOUT PROCEDURES

J. Contractor shall provide complete diagrams of the control system including flow diagrams with each control device labeled, a diagram showing the termination connections, and an explanation of the control sequence. The diagram and sequence shall be framed and protected by glass and mounted next to controller.

K. Contractor shall provide as built diagram of network bus routing listing all devices on bus, once wiring is complete prior to scope completion.

END OF SECTION 23 09 00
SECTION 23 09 01 - INSTRUMENTS AND CONTROL ELEMENTS

1. GENERAL

1.1 Refer to Section 23 09 00 for instruments and control elements for this project.

END OF SECTION 23 09 01
SECTION 23 09 93 - SEQUENCE OF OPERATION

1. GENERAL

1.1 The sequences provided in this section are subject to minor modifications during shop drawing review phase and system start-up. These minor changes are usually due to the specific operating characteristics of the HVAC equipment actually installed and/or building dynamics. These minor sequence modifications shall be incorporated without additional charges to the Owner.

1.2 All control set points called out shall be adjustable through software.

1.3 Refer to drawings for sequences of operation.

END OF SECTION 23 09 93
1. GENERAL

1.1 SECTION INCLUDES

A. Above grade pipe, fittings, and joints for:
   1. Heating water piping system.
   2. Chilled water piping system.
   3. Heat recovery water piping system.
   4. Equipment drains and overflows.

B. Valves.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

   1. Record actual locations of valves.

F. Delivery, storage, and handling.

1.3 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

B. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

C. Where connecting ferrous and non-ferrous piping materials, use full-port ball valves with bronze construction or a galvanized steel dielectric nipples with plastic liner to separate piping materials.
D. Use gate, ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers or as shown on plans.

E. Use ball or butterfly valves for throttling, bypass, or manual flow control services or as shown on plans.

F. Use lug end butterfly valves to isolate equipment.

1.4 REGULATORY REQUIREMENTS

A. Conform to International Mechanical Code for installation of piping system.

B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state and local labor regulations.

C. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6 EXTRA MATERIALS

A. Provide two repacking kits for each size and valve type.

2. PRODUCTS

2.1 STEEL PIPING, FITTINGS, AND JOINTS

A. Applicable Systems

1. Heating water
2. Chilled water
3. Heat recovery water


D. Fittings (2-1/2" and larger): ASTM B16.9, steel butt weld fittings.

E. Joints (2" and smaller): Threaded.
F. Joints (2-1/2" and larger): AWS D1.1, welded.

G. Branch Tees: Weld-O-Lets and Thread-O-Lets are acceptable for branch piping when main piping is 1" or larger than branch piping.

H. Saddle Tees: Are acceptable for branch piping when main piping is 2" or larger than branch piping.

I. Unions (2" and smaller): 150 psig malleable iron, threaded.

J. Flanges (2-1/2" and larger): 150 psig forged steel, slip-on, 1/16 inch thick preformed neoprene gaskets.

2.2 COPPER TUBING, FITTINGS, AND JOINTS

A. Applicable Systems

1. Heating water
2. Chilled water
3. Heat recovery water
4. Equipment drains and overflows

B. Pipe: ASTM B88, Type L, hard drawn

C. Copper Tubing: ASTM B88, Type DWV, hard drawn piping on equipment drains and overflows ONLY.

D. Fittings and Unions (2" and smaller): ASME B16.22 wrought copper and bronze:


E. Joints (All sizes):

1. Copper to copper: AWS A5.8/A5.8M, BCuP-5 (15% silver), Copper-phosphorus alloy.
2. Copper to bronze or steel: AWS A5.8/A5.8M, BAg-1, Silver alloy.

F. Flanges (2-1/2" and larger): Bronze, 1/16 inch thick preformed neoprene gaskets.

2.3 DIELECTRIC NIPPLE

A. Electroplated steel nipple, complying with ASTM F 1545 and IAPMO PS 66.

1. Rated for 300 psig at 225 deg F.
2. Male threaded or grooved end connections.
3. Inert and noncorrosive propylene lining.

2.4 VALVES

A. CALIBRATED BALANCE VALVES

1. Pre-Set Balance Feature. Valves to be designed to allow Installing Contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with scheduled flow rates.
2. Valve Design and Construction. All valves shall have a calibrated orifice or venturi section, two ¼" threaded pressure tap ports with integral seals, and memory stop to retain the set position. Valves should be rated for 125 psig working pressure and 250 Deg. F maximum operating temperature.
3. Valves shall be selected based on flowrate, not on pipe size dimensions.
4. Preformed Insulation. All valves to be provided with molded insulation to permit access for balance and read-out.

B. BALL VALVES

1. Up To and Including 3 Inches:
   a. Bronze two piece body, stainless steel full-port ball on all systems, Teflon seats and stuffing box ring, lever handle with balancing stops, solder or threaded ends. Include stem extensions on valves used in insulated piping systems.

C. BUTTERFLY VALVES

1. 4 Inches and Larger:
   a. Body: Cast or ductile iron with resilient replaceable EPDM seat, lug ends, extended neck.
   b. Disc: Aluminum bronze on closed systems and stainless steel on open systems.
   c. Stem: Stainless steel, extended on insulated systems as required to allow valve operation without damage to the insulation.
   d. Operator (4” and smaller): 10 position lever handle with memory stop, gear drive.
   e. Operator (6” and larger): Handwheel, gear drive.
   f. Chainwheel: On valves 6” and larger and installed higher than 8-feet above finished floor, provide sprocket rim, brackets, and chain compatible with valve.

D. SWING CHECK VALVES

1. Up To and Including 2 Inches:
   a. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends.
2. Over 2 Inches:
   
a. Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

E. SPRING LOADED CHECK VALVES

1. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

3. EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION

A. Grooved pipe fittings and joints may only be used in accessible locations.

B. Where connecting ferrous and non-ferrous piping materials, use full-port ball valves with bronze construction or a galvanized steel dielectric nipples with plastic liner to separate piping materials.

C. Heating water connections to terminal units shall be copper (no steel).

D. Install all piping in accordance with ASME B31.9.

E. Route piping in orderly manner, parallel to building structure, and maintain gradient.

F. Install piping to conserve building space, and not interfere with use of space.

G. Group piping whenever practical at common elevations.

H. Sleeve pipe passing through partitions, walls and floors.

I. Slope piping and arrange to drain at low points.
J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

K. Refer to Section 23 05 29 and Section 23 05 48 for installation of supports and hangers.

L. Provide insulation clearance and access to valves and fittings in hangers and from structure and other equipment. Insulation shall be continuous through all hangers and supports. Refer to Section 23 07 19.

M. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with General Contractor and requirements of Section 23 05 00.

N. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

O. Install unions on both sides of each control valve and on one side of all other valves. Install unions on the equipment side of final connections to each piece of equipment. Unions are not required at flanged valves or equipment.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

Q. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

R. Install valves with stems upright or horizontal, not inverted.

S. Provide insulated valve stem extensions on all valves installed in insulated piping systems.

T. Install chainwheel operators on valves 6" and larger that are installed 8-feet above finished floor or greater. Extend chain down to maximum 5-feet above finished floor.

U. Where possible, pipe connections shall be installed with the branch piping connected to the top of the main/header. If this is not possible due to space constraints, a connection with the same vertical centerline is acceptable. Connections to the bottom of the main/header is not allowed.

V. Provide solid chrome plated steel escutcheons cover the sleeves and openings at walls and ceilings in exposed areas.

3.3 SYSTEM FLUSHING, FILLING, PRESSURE TESTING AND CLEANING

A. Flush, fill, pressure test and clean all new hydronic systems and parts of existing systems which have been altered, extended or repaired.

B. Flush and fill systems with all valves open to coils. Bleed air from coils and piping. Clean strainers. Refer to Section 23 25 00.
C. Pressure Test Procedure:

1. Reference Section 23 05 00 for minimum test pressures.
2. Submit copy of Pipe Pressure Test Log provided in section 23 05 00 for each section of piping tested. Refer to 23 05 00 for general pipe pressure testing requirements (i.e., test pressure gages, inspections, etc.).
3. Leave joints including welds uninsulated and exposed for examination during the test.
4. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
5. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
6. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
7. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure (but not less than 100 psi). The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test.
8. After the hydrostatic test pressure has been applied for at least 12 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

D. Clean systems. Refer to Section 23 25 00 for cleaning procedure.

END OF SECTION 23 21 13
SECTION 23 21 16 - HYDRONIC SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

A. Expansion and buffer tanks.
B. Air vents.
C. Air/dirt separators.
D. Strainers.
E. Relief valves.
F. Flexible connections.
G. Pipe guides.
H. Glycol feeder.
I. Glycol solution.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.
B. Submittals.
C. Project record documents
   1. Record actual locations of hydronic specialties.
D. Operation and maintenance data.
E. Qualifications
F. Delivery, storage and handling.

2. PRODUCTS
2.1 EXPANSION / BUFFER TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME SEC VIII, Division 1; supplied with National Board Form U 1, rated for working pressure of 125 psig, with flexible, replaceable, butyl rubber bladder sealed into tank and steel support stand.

B. Accessories: Pressure gauge and air-charging fitting, tank drain.

2.2 AIR VENTS

A. Manual Type: Short vertical sections of equal diameter pipe, up to 2”, to form air chamber, with ball valve, hose connection, and cap.

B. Automatic Type: Bronze body, nonferrous internal parts, noncorrosive metal float, 150 psig CWP, 240 def F maximum operating temperature.

2.3 AIR/DIRT SEPARATORS

A. Air/Dirt Separators:

1. Steel construction, rated for 150 psig, and entering velocity not to exceed 10 feet per second at specified water flow rate.
2. Unit shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system.
3. Dirt separation shall be at least 80% of all particles 30 micron or larger within 100 passes.
4. Internal bundle filling the entire vessel consisting of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections an equal distance for dirt separation. Bottom connection for use as a blowdown.
5. Integral mounting lugs on large units (14” and larger) for use with contractor-provided mounting legs.
6. Provide removable head option and ASME stamp.

B. Manufacturer: Subject to compliance with requirements, provide product by one of the following:

1. Spirotherm
2. Or equivalent.

2.4 STRainers
A. Size 2 inch and Under:

1. Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch Type 304 stainless steel perforated screen.

B. Size 2-1/2 inch to 4 inch:

1. Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch Type 304 stainless steel perforated screen.

C. Size 5 inch and Larger:

1. Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch Type 304 stainless steel perforated screen.

D. Provide blowdown valves where shown on plan.

2.5 SAFETY RELIEF VALVES

A. ASME Section IV certified pressure relief valve featuring a raised seat and non-mechanical disc alignment. Working parts and spring shall be isolated from any discharge by a high temperature resistant material. Valve shall be a Watts Regulator Company Series 174 A or equivalent.

1. Materials: Bronze body construction, non-metallic disc-to-metal seating.
2. Pressure Rating: 30 psi to 150 psi.
3. Maximum Temperature: 250 deg F.

2.6 FLEXIBLE CONNECTIONS

A. Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket, with threaded or flanged ends to match equipment, 150 psig CWP rating, 250 deg F maximum operating temperature, capable of withstanding 3/4" misalignment.

B. Flexible grooved coupling may be used at base mounted pumps. Provide Victaulic Model 77 or approved equivalent.

2.7 PIPE GUIDES

A. Pipe guides shall be radial alignment type consisting of standard wall pipe guide cylinder with base and split guide spider. Cylinder shall be split. Cylinder and spider shall be of adequate length to allow for the movement due to thermal expansion.

B. Guides shall be Adsco Model E, Hyspan Series 9500, or equivalent.
2.8 GLYCOL FEEDER

A. Mixing Tank: 55 gallon polyethylene drum with hinged cover. Fully supported by a carbon steel bottom mount stand, painted with water based enamel.

B. Control Panel: NEMA 4X with 2-position main power switch and light, 3-position, hand-off-auto, switch and light for gear pump, red low light and 15 A fuse.

C. Low Level Switch: Polypropylene side entry low level switch with 10 A relay.

D. Gear Pump: Includes PVC ball valve, flexible tubing and cast iron Y-strainer. Pump discharge tubing includes brass construction spring check valve, PVC piping, and ¼" NPT back tap pressure gauge.

E. Pressure Switch: ¼” NPT

F. Pressure Relief Valves: 50-250 PSI brass valve

2.9 GLYCOL SOLUTION

A. Inhibited propylene glycol and water solution mixed 35 percent glycol - 65 percent water, suitable for operating temperatures from -10 degrees F to 250 degrees F.

3. EXECUTION

3.1 INSTALLATION

A. Install specialties in accordance with manufacturer’s instructions and as shown on drawings.

B. Provide manual air vents at all system high points and in accessible locations.

C. Provide drain valves at all low points and in accessible locations.

D. Provide heat trap piping arrangement for all expansion tanks as shown on drawings or per manufacturer instructions.

E. Provide appropriately sized structural supports for air/dirt separators. Support air/dirt separator independently of piping system for larger sizes per manufacturer’s instruction.

F. Provide valved drain and hose connection on strainer blow down connection.

G. Provide flexible connectors on pump suction and discharge.
H. Provide flexible connectors on all pipe connections that serve vibration isolated mechanical equipment.

I. Provide full-size piping from relief valve outlet to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION 23 21 16
SECTION 23 21 23 - HVAC PUMPS

1. GENERAL

1.1 SECTION INCLUDES

A. In-line circulators.
B. Base mounted pumps.
C. Pump suction fittings.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.
B. Performance requirements.

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within ± 10 percent of scheduled performance and published operating curve.

C. Submittals.
D. Operation and maintenance data.
E. Qualifications.
F. Delivery, storage and handling.
G. Extra materials.

1. Provide one set of mechanical seals and gaskets for each pump.

2. PRODUCTS

2.1 IN-LINE CIRCULATORS

A. See pump schedule on drawings for performance requirements.
HVAC PUMPS

B. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 175 psig maximum working pressure.

C. Casing: Cast iron, with flanged pump connections.

D. Impeller: Dynamically balanced cast bronze meeting ASTM #B584, keyed to shaft using carbon steel key, lock washer and nut.

E. Bearings: Two, oil lubricated bronze or babbit sleeves.

F. Shaft: Alloy or stainless steel meeting SAE 1144 with copper alloy 110 or bronze sleeve, integral thrust collar.

G. Seal: Mechanical carbon rotating against a stationary ceramic seat, 250 degrees F maximum continuous operating temperature.

H. Drive: Flexible coupling.

2.2 BASE MOUNTED PUMPS

A. See pump schedule on drawings for performance requirements.

B. Type: Horizontal shaft, single stage, direct connected, radially split back-pull-out casing, for 175 psig maximum working pressure.

C. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

D. Impeller: Bronze, fully enclosed, keyed to shaft.

E. Bearings: Grease lubricated ball bearings.

F. Shaft: Alloy steel with bronze shaft sleeve.

G. Seal: Mechanical seals with carbon rotating against a stationary ceramic seat, 225 degrees F maximum continuous operating temperature.

H. Baseplate: Cast iron or fabricated steel.

2.3 Pump Suction Fittings:

A. Fitting: Angle pattern, cast-iron body, threaded for 1-1/2 inch and smaller, flanged for 2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder stainless steel strainer with...
HVAC PUMPS

3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.

B. Accessories: Adjustable foot support, blowdown tapping in bottom, gage tapping in side.

3. EXECUTION

3.1 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.

D. Provide line sized shut-off valve and pump suction fitting flexible connection on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.

E. Provide air cock and drain connection on horizontal pump casings.

F. Install base mounted pumps on concrete inertia pad and concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Section 23 05 00.

G. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.

H. Support pump fittings with floor mounted pipe and flange supports.

3.3 START-UP AND COMMISSIONING

A. Start-up pump in accordance to manufacturer written instructions.

B. Before and after start-up, perform the following preventative maintenance operations and checks:

1. Lubricate bearings.
HVAC PUMPS

2. Check, align and certify alignment of base mounted pumps prior to start-up. Pump alignment shall be certified by 3rd party testing agency using laser alignment procedures.

3. After pump is started, check for proper rotation, proper mechanical operation and motor load to ensure that pump is not overloaded. Close pump balancing valve as required to bring pump motor load within motor nameplate data.

4. Check pumps to ensure it is not air bound or cavitating.

5. After sufficient run time, remove, check and clean strainer as required. Repeat cleaning strainer until system is sufficiently flushed. Refer to Section 23 25 00, Chemical Water Treatment.

6. After completing start-up, replace pump strainer with permanent strainer.

C. Coordinate pump testing, adjusting and balancing with Balancing Contractor. Complete additional preliminary work required by Balancing Contractor.

END OF SECTION 23 21 23
SECTION 23 25 00 - CHEMICAL WATER TREATMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Cleaning of piping systems.
B. Chemical feeder equipment.
C. Chemical treatment.

1.2 REFERENCES

A. Reference Section 230500.

1.3 SUBMITTALS

A. Reference Section 230500.

1.4 PROJECT RECORD DOCUMENTS

A. Record actual locations of equipment and piping, including sampling points and location of chemical injectors.

1.5 OPERATION AND MAINTENANCE DATA

A. Reference Section 230500.

B. Provide material safety data sheets on all chemicals provided. Provide plastic laminated storage and handling instructions and mount in area where readily accessible for future referencing.

1.6 QUALIFICATIONS

A. Reference Section 230500.

1.7 REGULATORY REQUIREMENTS

A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for to public sewage systems.

B. Products Requiring Electrical Connection: Listed and classified by UL or testing firm acceptable to
the authority having jurisdiction as suitable for the purpose specified and indicated.

1.8 MAINTENANCE SERVICE

A. Furnish service and maintenance of treatment systems for a period of one year after project turnover to Owner.

B. Provide technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit. At a minimum the closed loop piping systems shall be laboratory-tested at the start-up of the equipment, and shall continue once per month through a period of one year after project turnover to Owner.

C. Provide laboratory and technical assistance services during this maintenance period.

D. Include two hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start up of systems.

E. Provide on site inspections of equipment during scheduled shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

1.9 MAINTENANCE MATERIALS

A. Provide maintenance materials.

B. Provide sufficient chemicals for treatment and testing during warranty period.

2. PRODUCTS

2.1 MATERIALS

A. System Cleaner:

1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
2. Biocide.

B. Closed System Treatment (Water):

1. Sequestering agent to reduce deposits and adjust pH.
2. Corrosion inhibitors.
3. Conductivity enhancers.
2.2 BYPASS (POT) FEEDER

A. 5 gallon capacity, welded steel construction complete with fill funnel, inlet, outlet connections and quick opening cap for working pressure of 300 psig.

3. EXECUTION

3.1 PREPARATION

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

B. Place terminal control valves in open position during cleaning.

C. Verify that electric power is available and of the correct characteristics.

3.2 CLEANING SEQUENCE

A. Concentration:

1. As recommended by manufacturer.
2. One pound per 100 gallons of water contained in the system.
3. One pound per 100 gallons of water for hot systems and one pound per 50 gallons of water for cold systems.

B. Hot Water Heating Systems:

1. Apply heat while circulating, slowly raising temperature to 160 degrees F (71 degrees C) and maintain for 12 hours minimum.
2. Remove heat and circulate to 100 degrees F (37.8 degrees C) or less; drain systems as quickly as possible and refill with clean water.
3. Circulate for 6 hours at design temperatures, then drain.
4. Refill with clean water and repeat until system cleaner is removed.

C. Chilled Water Systems:

1. Install temporary 4” bypass and bypass valve in incoming chilled water supply and return lines directly downstream of the main shutoff valves. Close main shutoff valves and fill system.
2. Circulate for 48 hours, then drain systems as quickly as possible.
3. Refill with clean water, circulate for 24 hours, then drain.
4. Refill with clean water and repeat until system cleaner is removed.

D. Heat Recovery Water Systems:
1. Circulate for 48 hours, then drain systems as quickly as possible.
2. Refill with clean water, circulate for 24 hours, then drain.
3. Refill with clean water and repeat until system cleaner is removed.

E. Steam Systems:

1. Isolate all system components that are open to the surrounding air, including but not limited to steam humidifiers.
2. Fill system, circulate as possible, then drain system.
3. Refill with clean water and repeat until system cleaner is removed.

F. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.

G. Flush glycol filled closed systems with clean water for one hour minimum. Drain completely and refill.

H. Remove, clean, and replace strainer screens.

I. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.4 CLOSED SYSTEM TREATMENT

A. Provide one bypass feeder on each system or as shown on the Drawings. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.

B. Introduce closed system treatment through bypass feeder when required or indicated by test.

END OF SECTION 23 25 00
SECTION 23 29 23 – VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1. GENERAL

1.1 SECTION INCLUDES

A. Variable frequency controllers.

1.2 REFERENCE STANDARDS


C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.


1.3 SUBMITTALS

A. See Section 01 33 00 – Submittal Procedures.

B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

D. Test Reports: Indicate field test and inspection procedures and test results.

E. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

F. Manufacturer’s Field Reports: Indicate start-up inspection findings.

G. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
1.4 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience and with service facilities within 200 miles of Project.

C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

PART 2. PRODUCTS

2.1 MANUFACTURERS

A. Toshiba; Model Q9+ or Model AS3: www.toshiba.com

B. ABB; Model ACH550: www.abb.com

C. Yaskawa; Model Z1000 www.yaskawa.com

2.2 DESCRIPTION

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.

1. Employ microprocessor-based inverter logic isolated from power circuits.
2. Employ pulse-width-modulated inverter system.
3. Include a DC link reactor for reduction of harmonic distortion.
4. The controller, and all associated components, shall be supplied by a single vendor.
5. The controller will be operating a variable volume fan motor, or water pump motor for HVAC application.
6. System voltage shall be indicated on front of ASD, using minimum of 1-inch high letters.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public. No disconnects in VFD cabinet. Disconnect must be in separate enclosure.

2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage for motors rated below 40 HP: 200 volts, three phase, 60 Hertz, with a voltage tolerance of +/- 10% and a frequency tolerance of +/- 2 Hz.

B. Rated Output: Output frequency shall vary between 0.1 Hz and 400 Hz. Frequency resolution shall be 0.01 Hz digital and 0.03 Hz analog with an accuracy of +/-0.2% of maximum frequency at 25 degrees Celsius. Maximum voltage frequency shall be adjustable from 25 Hz to 400 Hz. Voltage boost shall be adjustable from 0% to 30% with starting frequency adjustable from 0 Hz to 10 Hz. The output current shall be 100% continuous and 110% for 60 seconds, based on NEC table 430-150 (Full-Load Current, Three-Phase Alternating Current Motors) for 200 volts or 460 volts.

C. The controller shall contain three critical frequency jump points with individual bandwidth. Upper and lower frequency limits shall be capable of being varied.

D. The PWM carrier frequency shall be adjustable from 5000 Hz to 15000 Hz.

E. The drive shall contain two separate acceleration/deceleration times (0.1 to 6000 seconds) with a choice of linear, S, or C curves. The drive shall have a standard dynamic electric braking for motors rated 30 HP or below. The drive shall restart into a rotating motor by sensing the coasting motor speed and matching that frequency. The drive shall have adjustable soft stall (10%-150%) and adjustable electronic overload protection (10%-100%).

F. The drive shall have external fault input, be capable of re-setting faults remotely and locally.

G. Input Signal:
   1. 0 to 10 v DC.
   2. 0 to 5 v DC.
   3. 4 to 20 mA DC.

H. Manual bypass is not required on VFD unless indicated on bid documents.

2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current, output power (kw), and motor RPM.
PART 3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA ICS 7.1, manufacturer’s instructions, and per drawings.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Provide engraved plastic nameplates; refer to Section 26 05 53 for product requirements and location.

D. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

E. When remote service disconnect is required, provide with auxiliary contacts hardwired to VFD safety circuit to shut down VFD, if disconnect is opened.

3.2 FIELD QUALITY CONTROL

A. Prior to initial energization, provide the service of the manufacturer’s field representative to prepare and start controllers.

3.3 MAINTENANCE

A. Furnish two extra of each air filter.

B. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

END OF SECTION 26 29 23
1. **GENERAL**

1.1 **SECTION INCLUDES**

A. Metal ductwork.

B. Duct cleaning.

C. Sheet metal plenums.

1.2 **REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:**

A. References.

B. Performance requirements.

1. No variation of duct configuration or sizes shall be permitted except by written permission.

C. Submittals.

1. Submit detailed CAD-generated ductwork drawings at minimum ¼” scale, with details of the following:

   a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   b. Duct layout indicating pressure classification and sizes on plans.
   c. Seam and joint construction.
   d. Penetrations through fire-rated and other partitions.
   e. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

**NOTE:** No installation of ductwork shall be allowed until detailed shop drawings have been reviewed by the Engineer. Any ductwork that is installed prior to the Engineer’s review of the shop drawings shall be subject to removal and replacement at the Contractor’s expense.

D. Project record documents.

1. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

E. Quality assurance.
1. Perform Work in accordance with the following standards:
   b. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
   c. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.
   e. SMACNA – HVAC Duct Construction Standards - Metal and Flexible.
   f. SMACNA - Round Industrial Duct Construction Standards

F. Qualifications.
   1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
   2. Installer: Company specializing in performing the work of this section with minimum five years experience.

G. Regulatory requirements.
   1. Construct all ductwork per codes listed in section 1.2.E

1.3 Environmental requirements.

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures during and after installation of duct sealants.

2. PRODUCTS

2.1 MATERIALS


B. Stainless Steel Ducts: ASTM A 480/A 480M, Type 316 sheet form with No. 4 finish for surfaces of ducts exposed to view, and Type 304 sheet form with No. 1 finish for concealed ducts.

C. Insulated Flexible Ducts:
   1. UL 181, Class 1, mechanically-locked spun nylon fabric supported by helically wound spring steel wire; fiberglass insulation; fire retardant polyethylene vapor barrier film.
2. Pressure Rating: 6 inches WG positive, 5.0 inches WG negative (through 16” diameter), 1.0’ WG negative (18” to 20”).


4. Temperature Range: -20 degrees F to 250 degrees F.

   
   a. 63 Hz Octave Band: 13
   b. 125 Hz Octave Band: 37
   c. 250 Hz Octave Band: 31
   d. 500 Hz Octave Band: 34
   e. 1 kHz Octave Band: 37
   f. 2 kHz Octave Band: 47
   g. 4 kHz Octave Band: 34

6. Manufacturer: Flexmaster Type 6B or equivalent.

D. Fasteners: Rivets, bolts, or sheet metal screws.

E. Sealant: ASTM E84 and UL rated, NFPA 90A and 90B approved, Non-hardening, water resistant, fire resistive, compatible with mating materials; and rated for all pressure duct systems. Fabric and metal backed duct tapes are not acceptable.

F. Hanger Rod: ASTM A36; steel or galvanized, threaded.

2.2 SHOP FABRICATED DUCTWORK

A. Fabricate, reinforce and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Construct T’s, and elbows in accordance with SMACNA HVAC Duct Construction Standards-Metal and Flexible, latest edition, using radius of not less than 1-1/2 times width of duct on centerline. Where mitered rectangular elbows are used or indicated, provide dual wall airfoil turning vanes.

C. Reference SMACNA figure 2-9 to construct gradual transitions where ductwork changes size or offsets.

2.3 MANUFACTURER FABRICATED DUCTWORK

A. Fabricate, reinforce and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
B. Round and oval duct shall be spiral lockseam duct with light reinforcing corrugations unless indicated otherwise.

C. Construct T's, bends, and elbows with minimum bend radius elbows shall be 1.5 times the duct diameter (major or minor axis on oval ductwork depending on direction of bend). Where not possible and where mitered elbows are used or indicated, provide double wall airfoil turning vanes.

D. Fabricate round and oval duct; fittings in accordance with SMACNA Standards. Joints shall be minimum 2 inch insertion length for joint connections.

E. Weld ductwork is to be weld with filler rod of the same material as the metal that is being welded. Coat welded joints with protective paint to prevent damage to galvanized surfaces.

F. On round and oval ducts, provide 45 deg wye tee take-offs or 90 deg conical tee take-offs or 45 degree low loss entry tee take-offs or other fitting as indicated on plans. Straight taps are not acceptable.

2.4 TRANSVERSE DUCT CONNECTION SYSTEM – RECTANGULAR DUCT

A. Slide on flange system: Ductmate and Ductmate WDCI connection system complete with interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips. Gasket material shall be chemical resistant material in all fume exhaust ductwork.

B. Formed on flange system: TDC, TDF or equivalent connection system or equivalent. Such flanges shall be constructed as SMACNA T-24 flange (Page 1-25 and 1-37 85 SMACNA Duct Construction Manual, 1985 Edition).

2.5 TRANSVERSE DUCT CONNECTION SYSTEM – ROUND AND OVAL DUCT

A. Slip type connector: Keating coupler.

B. Slide on flange system. Spiralmate and Ovalmate connection system complete with interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

C. Formed on flange system: Factory-applied Van Stone connection on one end of the duct with field-applied Van Stone connector on the other end of the duct. Provide factory-applied Van Stone connections on each end of fittings.

2.6 LOUVER BACKPAN

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and NFPA 96.

B. Construct of 18-gage galvanized steel using continuous external welded joints.
C. Welded ductwork is to be welded with filler rod of the same material as the metal that is being welded. Prime coat and paint welded joints with cold galvanized paint.

D. Slope bottom to prevent accumulation of water. Provide drains as necessary.

2.7 DOUBLE WALL, PRE-MANUFACTURED SHEET METAL PLENUMS (OUTSIDE AIR PLENUM, RELIEF AIR PLENUM)

A. General: Double wall, insulated pressurized plenum equipment shall be provided as indicated on the drawings. All panels and components shall be prefabricated and supplied by a nationally recognized manufacturer with published standards of construction, assembly and technical performance. Provide plenum as manufactured by McGill Airflow or equivalent.

B. The entire plenum installation shall be designed by the plenum manufacturer to be self-supporting. Where roof spaces or loading require additional strength, it shall be provided by heavier panel skins, additional structural members and necessary pipe columns. The installer shall furnish and install all such additional structural members according to the drawings and details furnished by the plenum manufacturer.

C. The finished plenum shall be able to withstand a positive internal static pressure of 4” and a negative internal static pressure of -4”. Under these static conditions, the assembled structure shall not exhibit any panel joint deflections in excess of L/200 where L is the unsupported span length of any panel section within the completed plenum.

D. Joint Construction: Snap-lock type with continuous self locking joint on both inside and outside of panel surface.

E. All panels shall be 4” thick with solid galvanized exterior shell and a solid galvanized interior shell as noted on the drawings and mechanical equipment schedule.

F. Outer shall be constructed of minimum 18-ga. galvanized sheet metal. Inner shell shall be constructed of minimum 22-ga. galvanized solid sheet metal.

G. Assembly Trim: Minimum 18-ga. hot-dipped galvanized steel furnished in standard lengths to be field cut.

H. All perimeter and longitudinal steel channel shall be constructed of ASTM Type A-446 structural quality galvanized steel with a minimum of 18 gage thickness or ASTM Type A-526 galvanized steel with a minimum of 16 gage thickness.

I. Each panel assembly shall be completely filled acoustical/thermal insulating material that is inert, mildew and mold resistant as well as vermin proof. Insulation shall have a flame spread rating of 25 and smoke developed rating of 50.
J. Thermal Performance: Insulating materials shall have a maximum thermal conductance of 0.06 Btu / Hr per square foot per Deg F (@ 75 Deg F mean temperature).

K. Personnel Access Doors: Provide personnel access doors where shown on the plans. Door sizes shall be 36”W x 66”H. All access door panels and doors shall be constructed of 18-ga. solid galvanized steel inner liner and galvanized outer shell. Each door shall have a minimum of two ball bearing hinges and two wedge-lever door handles. All levers shall be operable from inside or outside the casing. Door swings shall be as indicated on the plans. Doors shall seat against neoprene gasket material, installed around entire perimeter of door. Provide 12” square viewing windows which are composed of double-glazed layers of wire reinforced safety glass separated by an air space and sealed with rubber seals.

L. Plenum construction shall be fully coordinated with other trades to accommodate walls, floor, structure, piping, and other components in the vicinity. All penetrations and joints shall be sealed airtight.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions; SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition and International Mechanical Code requirements.

B. Seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition.

C. Drawings indicate general arrangement of ducts, fittings, and accessories.

D. Construct and install each duct system for the specific duct pressure classification indicated.

E. Install round in lengths not less than 12 feet, unless interrupted by fittings.

F. Install ducts with fewest possible joints.

G. Install fabricated fittings for changes in directions, changes in size and shape, and connections.

H. Install only low loss high efficiency fittings at takeoffs. Extractors not allowed.

I. Install couplings tight to duct wall surface with a minimum of projections into duct.

J. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
K. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

L. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness.

M. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

N. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

O. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

P. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.

Q. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Firestopping."

R. Verify location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to reflected ceiling plans, finish schedule, material finish specification, and shop drawings.

S. Coordinate routing with all other trades to establish space requirements for each.

T. Contractor may vary route and shape of ductwork and make offsets during progress of work if required to meet structural or other interferences. Where such changes impair the system performance, the changes will be corrected at Contractor’s expense.

U. All ductwork shall be substantially and neatly supported on galvanized steel straps or angles riveted or bolted to duct flanges and properly anchored to the construction so that horizontal ducts are without sag or sway, vertical ducts are without buckle, and all ducts are free from the possibility of deformation, collapse or vibration. Support at each joint and at 4 feet on center maximum.

V. Openings required for ductwork through structural elements in new construction shall be coordinated with the General Contractor. Shop drawings locating such openings shall be prepared in ample time to meet the construction schedule.

W. Provide sleeves at all duct penetrations through walls, floors and roofs. Openings through sound-rated partitions shall have annular space stuffed with fiberglass insulation for full thickness of wall.
X. Provide 2-inch deep bitumastic coated drip pans on all non-ducted hoods, fans or penthouses used for relief or exhaust air service. Pans shall be 12 inches larger all around than roof opening with clear vertical openings between pan and structure as indicated. Insulate pan where indicated.

Y. Install automatic control dampers as recommended by the manufacturer.

Z. Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safing material.

AA. Provide openings in ductwork to accommodate thermometers and controllers. Provide pitot tube openings for testing of systems, complete with metal cap with spring device or screw to prevent air leakage.

BB. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

CC. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Keep openings covered until ready for continuing duct run or final connections.

DD. Paint ductwork visible behind wall-mounted air outlets and inlets matte black.

EE. Change duct sizes gradually, not exceeding 30 degrees (15 degrees ideally) divergence and 45 degrees (30 degrees ideally) convergence.

FF. Use crimp joints with or without bead for joining round duct sizes 8 inches and smaller and install with crimp in direction of air flow.

GG. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.

HH. Provide return air grilles open to ceiling plenum with duct boot with minimum longitudinal dimension 2’ X 2’.

II. Provide flexible connect between ductwork and all moving equipment.

1. Provide 1-inch slack for free movement.

JJ. Join VAV boxes to medium pressure supply duct mains with minimum straight length of duct equal to 5 times box inlet diameter size. Duct to be rigid. Flexible ductwork is not allowed to join boxes to supply duct main.

KK. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA’s “Duct Cleanliness for New Construction”.
LL. Threaded cap test holes shall be provided in all ductwork. Test holes shall be installed after the reheat coil in all VAV boxes. Provide extensions to allow for insulation thickness. Test holes shall be “Ventlok” or equal.

MM. Exterior Ductwork:

1. Slope top of rectangular ductwork to allow proper drainage.
2. Utilize PHP systems or equivalent roof supports with galvanized channels for exterior ductwork. For support loading and spacing, use manufacturer recommendations.

3.2 GENERAL

A. Install in accordance with manufacturer’s instructions; SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition and International Mechanical Code requirements.

B. Seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition.

C. Duct sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

D. Provide openings in ductwork where required to accommodate thermometers and controllers.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. Cover all exposed fiberglass insulation with duct tape.

G. During construction provide temporary closures of metal or tape polyethylene on open ductwork to prevent construction dust from entering ductwork system.

H. Connect flexible ducts to metal ducts with stainless steel bands with worm gear tightener, nylon bands are unacceptable.

I. Duct transition from round to rectangular and vise versa shall be made with rectangular to round duct transition fitting.

J. Provide flange-type joint at transverse joints or seal as specified. All transverse joints shall be inspected by the Owner prior to insulating ductwork.

K. Duct work upstream of air terminal units shall be rigid duct with minimum three diameters of straight ductwork upstream of air terminal units.

L. Air terminal take-offs from rectangular main ducts shall be lo-loss 45°F take-offs, extractors are not allowed.
M. Diffusers and register take-offs from rectangular duct mains shall be lo-loss 45° fittings, with integral balancing damper that is provided with stand-off bracket and quadrant lock. Extractors are not allowed.

N. Do not exceed 6’ of flexible duct upstream of each diffuser or grille. See details on Drawings.

O. Exhaust grille/register branch duct connections to rectangular mains shall be lo-loss 45° entry fittings with integral balancing damper.

P. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

Q. Plenum construction shall be fully coordinated with other trades to accommodate walls, floor, structure, piping, and other components in the vicinity. All penetrations and joints shall be sealed airtight.

3.3 INSTALLATION OF 2” AND GREATER PRESSURE CLASS DUCTWORK (POSITIVE OR NEGATIVE PRESSURE)

A. All round and oval duct elbows installed shall be die-formed, gored, pleated or mitered. All mitered elbows shall be equipped with turning vanes.

B. On round and oval ducts, provide 45 deg wye or 90 deg conical tee take-offs as indicated on plans. Straight taps are not acceptable.

C. All diverging flow fittings shall be constructed such that no excess material projects from the body into the branch tap entrance.

D. Transverse joints of all rectangular ducts greater than 24” wide or deep shall be fabricated with flanging system as called out previously (Ductmate or equivalent).

3.4 INSTALLATION OF 1” AND LESS PRESSURE CLASS DUCTWORK (POSITIVE OR NEGATIVE PRESSURE)

A. All round duct elbows installed shall be of the adjustable, die-formed, gored, pleated or mitered type. All adjustable elbows shall be sealed after installation.

B. All mitered elbows shall be equipped with turning vanes.

C. Connect ceiling diffusers to low pressure ducts with adjustable elbow at duct and short length of flexible duct held in place with strap or clamp. Do not use flexible duct to change direction. Connection detail as well as maximum length of flex duct allowed to diffusers is indicated on the plans.

3.5 PLENUMS
A. General

1. Unless otherwise noted, mount casings on 4-inch high concrete curbs.

3.6 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Exposed ductwork serving ventilated workstations and corrosive storage cabinets:

1. Install the exposed stainless steel ductwork serving the ventilated workstations with the longitudinal weld facing the adjacent wall and away from public view. If possible, install one continuous exposed duct without transverse joints. Install escutcheon ring at ceiling penetration. Ring shall be same material and same finish as exposed duct. Note that exposed ductwork shall be provided with a No. 4 finish. Verify acceptable appearance of installed ductwork with Architect after installation.

3.7 CLEANING

A. The air handling units, energy recovery wheel, exhaust fans, and other HVAC airside equipment shall not be used for temporary building conditioning without the written permission from the Owner and Architect/Engineer. Open ductwork that has been installed shall be protected during the duration of the project with polyethylene plastic and duct tape over the open ends. Uninstalled ductwork shall be protected from construction dust by covering the uninstall ductwork with polyethylene plastic. Prior to installing ductwork, the inside of the ductwork shall be wiped down or vacuumed.

B. Clean inside all air handling units, energy recovery units, and outside air duct systems before the fans are turned on. Call for inspection by the owner’s representative to verify that all ducts are cleaned. If the ductwork is unacceptable, the contractor shall provide vacuuming of these duct systems by forcing air at high velocity through duct where manual cleaning in not possible due to duct lengths or size. Call for re-inspection by Owner’s representative.
C. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

D. Call for inspection by Owner's representative.

E. Install a fresh set of filters in all equipment immediately prior to project turnover.

3.8 DUCTWORK SCHEDULE

<table>
<thead>
<tr>
<th>Duct System:</th>
<th>Material:</th>
<th>Longitudinal Joints:</th>
<th>Transverse Joints:</th>
<th>Pressure Class:</th>
<th>Sealant Class:</th>
<th>Leakage Class:</th>
<th>Additional Notes:</th>
</tr>
</thead>
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<tr>
<td>Outside air system upstream of AHU</td>
<td>Galv. Steel</td>
<td>3A</td>
<td>4A, 4C</td>
<td>-2&quot;</td>
<td>B</td>
<td>24</td>
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<td>Rectangular SA system upstream of terminal units</td>
<td>Galv. Steel</td>
<td>3A, 3E</td>
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<td>8B</td>
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<td>Round SA system upstream of terminal units</td>
<td>Galv. Steel</td>
<td>3C, 3E</td>
<td>4B, 4D</td>
<td>+6&quot;</td>
<td>A</td>
<td>3</td>
<td>8B</td>
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<tr>
<td>Rectangular SA system downstream of terminal units</td>
<td>Galv. Steel</td>
<td>3A, 3B, 3E</td>
<td>4A, 4C, 4D</td>
<td>+2&quot;</td>
<td>A</td>
<td>24</td>
<td>8B</td>
</tr>
<tr>
<td>Round SA system downstream of terminal units</td>
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<td>3C, 3E</td>
<td>4B, 4D</td>
<td>+2&quot;</td>
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<td>12</td>
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<td>Rectangular general EA or RA system upstream of terminal unit</td>
<td>Galv. Steel</td>
<td>3A, 3B, 3E</td>
<td>4A, 4C, 4D</td>
<td>-2&quot;</td>
<td>A</td>
<td>24</td>
<td>8B</td>
</tr>
<tr>
<td>Round general EA or RA system upstream of terminal unit</td>
<td>Galv. Steel</td>
<td>3C, 3E</td>
<td>4B, 4D</td>
<td>-2&quot;</td>
<td>A</td>
<td>12</td>
<td>8B</td>
</tr>
<tr>
<td>Rectangular general EA or RA system downstream of terminal unit</td>
<td>Galv. Steel</td>
<td>3A, 3E</td>
<td>4A, 4C, 4D</td>
<td>-6&quot;</td>
<td>A</td>
<td>6</td>
<td>8B</td>
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<tr>
<td>Round general EA or RA system downstream of terminal unit</td>
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<td>4B, 4D</td>
<td>-6&quot;</td>
<td>A</td>
<td>3</td>
<td>8B</td>
</tr>
<tr>
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<td>4D</td>
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**DUCTWORK SCHEDULE NOTES:**

**Longitudinal Joint Options:**
3A: Pittsburgh lock. Refer to Figure 1-5, SMACNA.
3B: Button punch snap lock. Refer to Figure 1-5, SMACNA.
3C: Spiral lockseam.
3D: Snaplock.
3E: Welded.
3F: Double-wall, pre-manufactured sheet metal plenum.

**Transverse Joint Options:**
4A: Pre-manufactured flanged duct connection system specified under “Products” section of this specification.
4B: 0-24” Major Axis Diameter: Interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening. 26” Major Axis Diameter and Up: Pre-manufactured flanged duct connection system specified under “Products” section of this specification.
4C: Any standard transverse joint as shown in Figure 1-4 of SMACNA is acceptable.
4D: Welded

**Sealant Class Options:**
6: Seal class is defined by the following table (refer to Table 4-1, SMACNA HVAC Air Duct Leakage Test Manual):

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<th>Seal Class</th>
<th>Sealing Required</th>
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<tbody>
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<td>A</td>
<td>All transverse joints, longitudinal seams, and ductwork penetrations. Pressure sensitive tape shall not be used as a primary sealant on metal ducts.</td>
</tr>
<tr>
<td>B</td>
<td>All transverse and longitudinal seams. Pressure sensitive tape shall not be used as a primary sealant on metal ducts.</td>
</tr>
<tr>
<td>C</td>
<td>Transverse joints only.</td>
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</table>

**Leakage:**

<table>
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<th>Duct System:</th>
<th>Material:</th>
<th>Longitudinal Joints:</th>
<th>Transverse Joints:</th>
<th>Pressure Class:</th>
<th>Sealant Class:</th>
<th>Leakage Class:</th>
<th>Additional Notes:</th>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>4D</td>
<td>-2”</td>
<td>A</td>
<td>3</td>
<td>8B</td>
</tr>
<tr>
<td>Rectangular fume EA system downstream of terminal unit</td>
<td>Stainless Steel</td>
<td>3E</td>
<td>4D</td>
<td>-6”</td>
<td>A</td>
<td>6</td>
<td>8B</td>
</tr>
<tr>
<td>Round fume EA system downstream of terminal unit</td>
<td>Stainless Steel</td>
<td>3E</td>
<td>4D</td>
<td>-6”</td>
<td>A</td>
<td>3</td>
<td>8B</td>
</tr>
</tbody>
</table>
7: Leakage Class is defined by Figure 4-1, SMACNA HVAC Air Duct Leakage Test Manual.

Additional Comments:
8A: See Drawings for further information regarding extent of stainless steel ductwork.
8B: Field welded ductwork is to be welded with filler rod of the same material as the metal that is being welded. Field coat welded joints with protective paint to prevent damage to galvanized surfaces.

3.9 PRESSURE TESTING

A. Perform the following field tests and inspections according to SMACNA’s “HVAC Air Duct Leakage Test Manual” and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days’ advance notice for testing.
3. Maximum Allowable Leakage: Refer to paragraph 3.6.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.
5. Test no less than 25% of the supply air ductwork upstream of terminal units, 25% of the return air ductwork downstream of terminal units, 25% of the exhaust air ductwork downstream of terminal units, and 50% of the fume exhaust ductwork downstream of terminal units.

3.10 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

END OF SECTION 23 31 13
SECTION 23 33 00 - DUCTWORK ACCESSORIES

1. GENERAL

1.1 SECTION INCLUDES

A. Air turning devices.
B. Duct access doors.
C. Duct test holes.
D. Flexible duct connections.
E. Volume control dampers.
F. Gravity backdraft dampers.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.
B. Submittals.
C. Project record documents.
   1. Record actual locations of access doors, test holes etc.
D. Qualifications.
   1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
E. Regulatory requirements.
   1. Products Requiring Electrical Connection: UL Listed and classified.
F. Delivery, storage, and handling.
   1. See Section 23 05 00.
G. Extra materials.
1. Provide two of each size and type of fusible link for fire and combination fire/smoke dampers.

2. PRODUCTS

2.1 AIR TURNING DEVICES

A. Note that air extractors or "scoops" shall not be used under any circumstances.

B. General:
   1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
   2. Note that air extractors or "scoops" shall not be used under any circumstances.

C. Manufactured and Fabricated Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   2. Single-Thickness Vane Construction: Vanes shall be single-thickness, quarter-circle shape with 2" radius, minimum 3.15" length, and spaced 1.5" on center.
   3. Double-Thickness Vane Construction: Vanes shall be double-thickness, quarter-circle shape, with 4.5" radius and spaced 3.25" on center.

2.2 DUCT ACCESS DOORS

A. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.
   1. Less Than 12 Inches Square: Secure with sash locks.
   2. Up to 18 Inches Square: Provide two hinges and two sash locks.
   3. Up to 24 x 48 Inches: Three hinges and two compression latches with outside and inside handles.
   4. Larger Sizes: Provide an additional hinge.

B. Access doors with sheet metal screw fasteners are not acceptable.

2.3 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.
2.4 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Construct flexible connector of neoprene coated flameproof fabric crimped into duct flanges for attachment to duct and equipment.

2.5 VOLUME CONTROL DAMPERS

A. Fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

   1. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
   2. Operator: Minimum 3/8 inch square shaft with nylon end bearings at each end to reduce air leakage.

B. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. End Bearings: Except in round ductwork 6 inches and smaller, provide nylon end bearings on each end. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

E. Quadrants:

   1. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Regulator shall be equivalent to Sheet Metal Connectors Model RP-3, with heavy-gauge steel regulator, wing nut locking assembly, and stamped dial indicating damper position.
   2. On externally insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters to avoid damaging or compression of insulation.
   3. Where rod lengths exceed 30 inches, provide regulator at both ends.

F. Remote damper actuators:

   1. Provide Young Regulator model 270-896C or equivalent remote volume damper actuator when volume control damper is located above non accessible ceilings. Provide necessary Bowden cable and match manual volume control damper to make for a complete and operable system.

2.6 TAKEOFFS
DUCTWORK ACCESSORIES

A. Manufactured high-efficiency takeoff with 45-degree slope on the body, with gauge thickness equal to adjacent ductwork.

2.7 GRAVITY BACKDRAFT DAMPERS

A. Gravity Backdraft Dampers, Size 18 x 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturers standard construction.

B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: [16 gage thick extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

3. EXECUTION

3.1 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 13 for duct construction and pressure class.

B. Provide duct access doors:
   1. For inspection and cleaning before and after filters, coils, fans, automatic dampers.
   2. Elsewhere as indicated on plans.

C. Unless duct access door size is explicitly indicated, provide minimum 24 x 18 inch size duct access doors wherever possible. Provide 18 x 18, 12 x 12 inch or 8 x 8 inch size elsewhere, using the largest size possible.

D. Provide duct test holes where indicated and required for testing and balancing purposes. Install with minimum 24” clear dimension from any side wall or other obstruction.

E. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. Install flexible connectors with adequate flexibility to allow for all thermal, axial, transverse and torsional movement. Provide airtight seal. For fans developing static pressures of 5.0 inches and over, cover connections with leaded vinyl sheet, held in place with metal straps.

F. Provide balancing dampers at points on supply, return, and exhaust systems where indicated on plans.
G. Provide a high-efficiency takeoff with 45-degree entry for each branch connection.

H. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

I. The use of splitter dampers is not acceptable.

J. Install remote manual volume control damper actuators where the volume damper is not accessible. Install all actuator assemblies serving the same room in the same location above the ceiling and near a return air grille or access panel. Label each actuator with the location of the diffuser or grille that it serves.

1. If an actuator is required to be installed in a ceiling, its location shall be coordinate with the Architect prior to installation and the smallest possible ceiling open and cover shall be provided. Covers should be painted as necessary to match adjacent surfaces.

END OF SECTION 23 33 00
SECTION 23 34 13 – HIGH-PLUME DILUTION LABORATORY EXHAUST SYSTEM

1. GENERAL

1.1 SECTION INCLUDES

A. High-Plume Dilution Laboratory Exhaust System
   1. Corrosion resistant coating
   2. Fan housing and outlet
   3. Fan impeller
   4. Bypass air plenum
   5. Bypass air plenum curb
   6. Fan motors and drive

1.2 QUALITY ASSURANCE

A. Performance ratings: Conform to ANSI/AMCA Standards 210, 260 and 300. Fans must be tested in accordance with AMCA Publications 211, 260 and 311 in an AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210), sound performance (AMCA 300), and induced flow fan for high plume dilution blowers (AMCA 260). Manufacturers that are not licensed to bear the AMCA 210 and 260 ratings seal, must provide performance witness testing (at the manufacturer's expense), per paragraph 1.4.D.

B. Classification for Spark Resistant Construction shall conform to ANSI/AMCA Standard 99.

C. Each fan shall be vibration tested before shipping, as an assembly, in accordance with ANSI/AMCA Standard 204. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial. The maximum allowable fan vibration shall be less than 0.10 in. /sec peak velocity; filter-in reading as measured at the fan RPM. This report shall be provided at no charge to the customer upon request.

D. Manufacturers that do not comply with paragraph 1.2.A must also provide, at the owner and engineer's option and manufacturer's expense, witness testing of fan discharge and entrainment airflow, performed in an AMCA accredited laboratory, in accordance with AMCA 210 and 260. This test shall verify the critical and safety related dilution performance of the high plume dilution blower, as stated by the manufacturer.

1.3 REFERENCES


B. ANSI/AMCA Standard 204-05, "Balance Quality and Vibration Levels for Fans"

C. ANSI/AMCA Standard 210-07, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"
D. AMCA Publication 211-05, "Certified Ratings Program - Product Rating Manual for Fan Air Performance"

E. AMCA Standard 260-07, "Laboratory Methods of Testing Induced Flow Fans for Rating"

F. ANSI/AMCA Standard 300-08, "Reverberant Room Method for Sound Testing of Fans"

G. AMCA Publication 311-05, "Certified Ratings Program – Product Rating Manual for Fan Sound Performance"

H. AMBA Method of Evaluating Load Ratings of Bearings ANSI-11 (r1999)

I. ANSI/AMCA Standard 500-D-12, "Laboratory Methods of Testing Dampers for Rating"

J. ANSI/AMCA Standard 500-L-12, "Laboratory Methods of Testing Louvers for Rating"

K. SMACNA - Medium Pressure Plenum Construction Standard

L. ANSI/AIHA Z9.5-2012 – Laboratory Ventilation

M. ASHRAE - Laboratory Design Guide


O. OSHA guideline 1910.219 – General requirements for guarding safe use of mechanical power transmission apparatus. (www.osha.gov)

P. OSHA guideline 1926.300 – General requirements for safe operation and maintenance of hand and power tools. (www.osha.gov)

Q. UL Standard 705, “Power Ventilators”

1.4 RELATED WORK

A. All sections, drawing plans, specifications and contract documents.

1.5 SUBMITTALS

A. Provide dimensional drawings and product data on each high-plume dilution laboratory exhaust fan assembly.

B. Provide fan curves for each fan at the specified operation point with the flow, static pressure and horsepower clearly plotted.

C. Provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume rise at specified wind velocity.

D. Strictly adhere to quality assurance requirements as stated in this specification.
1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation.

B. Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage, follow manufacturer’s Installation, Operation and Maintenance manual.

C. Handle and lift fans in accordance with the manufacturer’s instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

1.7 WARRANTY

A. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.

1. The warranty of this equipment is to be free from defects in material and workmanship for a period of 12 months from the purchase date. An optional 24 or 36 month warranty from the date of shipment shall be provided on the fan(s) only. Any units or parts which prove defective during the warranty period will be replaced at the manufacturers’ option when returned to the manufacturer, transportation prepaid.

2. Motor Warranty is warranted by the motor manufacturer for a period of one year. Should motors furnished prove defective during this period, they should be returned to the nearest authorized motor service station.

2. PRODUCTS

2.1 GENERAL

A. Manufacturer: The plans and specifications for the laboratory fume hood exhaust system are based on systems and equipment manufactured by Greenheck.

2.2 MIXED-FLOW INDUCED DILUTION FANS:

A. GENERAL

1. Base fan performance at standard conditions (density 0.075 Lb. /ft³).
2. Each fan selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be direct driven according to drawings.
4. Each fan to be equipped with 316 stainless steel lifting lugs for corrosion resistance.
5. Fasteners exposed to corrosive exhaust shall be stainless steel.
6. Curb cap shall be hot rolled steel coated with corrosion resistant coating.
7. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment shall not be acceptable.
8. Fan assembly shall be designed for a minimum of 125-mph wind loading, without the use of guy wires.
9. Motor cover shall be hinged with removable side panels for ease of maintenance to allow the servicing of the motor and drive.

B. CORROSION RESISTANT COATING

1. All fan and system components (fan, nozzle, windband and plenum) shall be corrosion resistant coated with a two part electrostatically applied and baked, sustainable, corrosion resistant coating system. Standard finish color to be RAL 7023, concrete grey.
2. All parts shall be cleaned and chemically prepared for coating using a multi-stage wash system which includes acid pickling that removes oxide, increases surface area, and improves coating bond to the substrate.
3. The first powder coat applied over the prepared surface shall be a zinc rich epoxy primer (no less than 70% zinc) and heated to a gelatinous consistency (partial cure) at which the second powder coat of polyester resin shall be electrostatically applied and simultaneously be cured at a uniform temperature of 400°F.
4. The coating system, a total thickness of up to 6 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000 hour ASTM B117 Salt Spray.

C. FAN HOUSING AND OUTLET

1. Fan housing shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
2. Fan housing shall be bifurcated, allowing all drive components, including the motor, to be serviced without contact of the contaminated airstream. Must be manufactured of welded steel and meet specification section 2.15 for corrosion resistant coating.
3. Fan housings that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and / or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
4. A multi-stage air induction discharge nozzle shall be supplied by the fan manufacturer, and be designed to efficiently handle an outlet velocity of up to 7000 FPM. The multi-stage nozzle shall induce ambient air up to 270% of fan capacity. Nozzle / windband assemblies that are manufactured by third party vendors or that are fabricated of plastic or resins, having mechanical properties less than steel shall not be acceptable.
5. An integral fan housing drain shall be used to drain rainwater when the fan is de-energized.
6. An access door shall be supplied for impeller inspection and service.
7. Fan assembly shall be AMCA type C spark resistant construction minimum or as noted on the schedule.

D. FAN IMPELLER

1. Fan impeller shall be mixed flow design with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically exceeding AMCA Standards.
2. Fan impeller shall be manufactured of welded and coated steel. Reference section 2.15 for corrosion resistant coating.
3. Fan impellers that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, and lower maximum tip speeds are not acceptable.
4. Vacuum Seal: Fan impeller shall include a secondary fan blade located on the impeller back plate. This secondary impeller shall create a negative pressure at the shaft opening; preventing hazardous or toxic exhaust fumes from escaping through the housing shaft opening. Mechanical shaft seals that wear out and need to be replaced or seal systems that use hoses or tubes that can leak, are not acceptable.

E. ENERGY RECOVERY COIL PLENUM
1. The energy recovery coil plenum shall be provided as shown on drawings.
2. The plenum casing deflection shall not exceed 1/200 of panel span at 1.5 times the fan static pressure.
3. Plenum construction consists of an all-welded structural steel base, a stainless steel tube and double wall insulated panels for walls, floor, interior partitions and roof. Construction shall be specifically designed for outdoor installation.
4. Plenum unit base shall be constructed of welded structural steel with removable lifting lugs. Base shall be coated with corrosion resistant grey urethane modified enamel.
5. Panels shall be two inch double-wall, 18 gauge corrosion resistant polyester coated pre-treated galvanized outer walls and 22 gauge, 304 stainless steel inner walls. Plenum insulation shall be no less than 2 Lb. /ft3, two inch thick foam in place polyurethane for additional structural rigidity. Panels shall be individually removable. Plenum floor shall be insulated with foam in place fiberglass insulation.
6. Plenum roof panels shall be a standing seam assembly fabricated of corrosion resistant 18 gauge corrosion resistant polyester coated pre-treated galvanized, and sloped. Panel edges shall extend beyond the edge of the plenum casing to ensure water drainage.
7. Fasteners exposed to corrosive exhaust shall be stainless steel.
8. Insulated double wall access doors, hinged and gasketed with tooled-entry handles shall be provided for access to any plenum areas requiring routine maintenance, both upstream and downstream of coil and filters, as shown on the project drawings.
9. A filter section shall be provided at the air inlet of the energy recovery coil plenum. Filter racks shall be 304 stainless steel. Filters will be mounted for side access and are sized for a maximum face velocity of 500 ft./min. Filter efficiency shall be two inch - 40% (MERV 8) or four inch - 65% (MERV 11) as specified.
10. Drain pan shall be 18ga, 304 stainless steel with raised coil supports.

F. ENERGY RECOVERY COIL
1. An ARI-410-2001 rated energy recovery coil(s) shall be provided within the energy recovery coil plenum, performance parameters as specified in the schedule.
2. The coil shall be constructed of a seamless copper tube primary surface with a wall thickness of 0.025 inch and an aluminum plate fin sine-wave surface with a thickness of 0.008 inch.
3. The coil shall be provided with copper headers and MPT carbon steel coil connections.
4. The coil casing shall be constructed of 304 stainless steel.
5. The coil shall be corrosion resistant coated with baked Heresite Phenolic resin (P413C).
6. The complete coil core is tested under water and guaranteed to withstand 450 PSIG of dry nitrogen.
7. Plenums with optional external mounted coil connections are sealed to insure low-air leakage of the negatively pressurized plenum.
8. **Coil connections shall be internal to the heat recovery section to allow piping to penetrate the roof through the equipment curb.**

**G. PLENUM CURB**

1. Plenum manufacturer shall supply a structural support curb for the plenum of specified height as shown on drawings.
2. Curb shall be fabricated of a minimum of 12 gauge welded steel, structurally reinforced and coated with LabCoat™ or equivalent.
3. Curb shall be internally insulated with one inch thick, 6 Lb. /ft³ density insulation.
4. When properly anchored to the roof structure, the curb and plenum assembly shall withstand wind loads of up to 125 mph without additional structural support.

**H. FAN BYPASS AIR PLENUM**

1. A bypass air plenum shall be provided as shown on drawings. The plenum shall be provided with bypass air damper(s) for introducing outside air at roof level upstream of the fan, complete with bypass air weatherhood and bird screen.
2. The plenum shall be a double-wall construction, LabCoat™ coated exterior with a stainless steel inner liner. Plenums fabricated of plastics or resins which are combustible and have mechanical properties less than steel shall not be acceptable.
3. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the project drawings.
4. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be permitted.
5. Bypass air damper(s) shall be opposed-blade design for airflow control, airfoil design, fabricated of galvanized steel for structural rigidity as standard. Bypass damper(s) shall have plated steel damper rods, stainless steel sleeved bearings, 301 stainless steel jamb seals and the blades shall have polymer edge seals. Damper model shall be equal to or exceed a heavy duty control damper, Greenheck HCD-130. Damper blade drive linkage shall be set by manufacturer and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated airstream.
6. An integral bypass air packed acoustic attenuator fabricated of galvanized steel shall be provided by the fan manufacturer.
7. Fan isolation damper(s), shall be parallel-blade design, airfoil design, fabricated of 304 stainless steel construction for structural rigidity as standard. Damper(s) shall be coated up to 4 mils of chemically resistant Hi-Pro Polyester resin, electrostatically applied and baked. Isolation damper(s) shall have stainless steel damper rods, stainless steel sleeved bearings, 301 stainless steel jamb seals and the blades shall have polymer edge seals. Damper model shall be equal to or exceed a heavy duty control damper, Greenheck HCD-130. Damper blade drive linkage shall be set by manufacturer and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated airstream.
8. Isolation damper actuator(s) shall be factory mounted and shall be wired to a step-down transformer. Actuator and transformer are located in a weatherproof enclosure.
9. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.
1. Motors shall be premium efficiency, standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. A factory-mounted NEMA 3R disconnect switch shall be provided for each fan.

2. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components. Drive arrangement shall be AMCA arrangement 9. Direct drive arrangement 4, or direct drive arrangements requiring access and handling of hazardous and contaminated fan components for motor replacement are not acceptable.

3. Fan shaft to be turned and polished of 316 stainless steel.

4. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 200,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use setscrews shall not be acceptable.

5. All shaft bearings and non-permanently lubricated motors shall have stainless steel braided extended lube lines with Zerk fittings.

J. FLOW MONITORING STATION

1. Flow monitoring station shall monitor the pressure difference between the fan inlet and the smallest diameter of the fan inlet cone.

2. Flow monitoring station shall not use air restricting flow devices that reduce fan performance or create additional fan sound.

3. A quantity of four equidistantly spaced sensor orifices shall be drilled in the smallest diameter of the inlet cone venture. Flow tubes from each venture sensor shall be extended to a termination plate mounted on the fan housing.

4. High-pressure flow port(s) shall be mounted in low velocity fan inlet. Flow ports from the high-pressure sensor shall extend to a termination plate mounted on the fan housing.

5. Termination plate shall include a low-pressure connection, a high-pressure connection and a listing of the empirically determined flow rate coefficient.

6. Flow monitoring station shall accurately measure the pressure differential to within +/- 3%.

K. OPTIONAL ELECTRONICS WITH DIGITAL READOUT

1. Fan manufacturer to select the pressure transmitter based on the estimated pressure differential between the fan inlet and fan venture.

2. Pressure transmitter to be accurate within +/- 0.5% of full scale @ 77°F (25°C).

3. Pressure transmitter shall provide a 4-20 mA linear output for interfacing with building control systems.

4. Differential pressure transmitter and digital readout to be housed in a NEMA 4 enclosure.

3. INSTALLATION

A. Install fan systems as indicated on the contract drawings.

B. Pipe housing drain(s) to nearest drain.

C. Install fans in accordance with manufacturer's instructions.
D. The air handling units, exhaust fans, and other HVAC airside equipment shall not be used for temporary building conditioning without the written permission from the Owner and Architect/Engineer.

END OF SECTION 23 34 13
SECTION 23 36 00 - AIR TERMINAL UNITS

1. GENERAL

1.1 SECTION INCLUDES

A. Variable volume terminal units.

B. Integral heating coils.

C. Integral damper motor operators.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of one to 4 inch wg (250 to 1000 Pa).

B. References.

C. Submittals.

D. Project record documents.

E. Operation and maintenance data.

F. Qualifications.

G. Regulatory requirements.

H. Warranty.

1. Operation and Maintenance Data: Include manufacturer’s descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

2. Products Requiring Electrical Connection: Listed and classified by Underwriters’ Laboratories Inc., as suitable for the purpose specified and indicated.

2. PRODUCTS

2.1 MANUFACTURED UNITS

A. Variable air volume air control terminals for connection to single duct central air systems, with digital variable volume controls.
B. Identify each terminal unit with clearly marked identification label and air flow indicator. Include unit nominal air flow, maximum factory set airflow, minimum factory set air flow, and coil type.

2.2 SINGLE DUCT VARIABLE VOLUME UNITS

A. See Drawings for further information.

B. Basic Assembly:

2. Liner: Fiber-free internal liner.
3. Air Outlets: S slip and drive connections.

C. Basic Unit:

2. Volume Damper: Construct of steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 4 percent of design air flow at three (3) inches inlet static pressure.
3. Mount damper operator to position damper normally open or normally closed as required by the operation sequence.
4. On units with heating coils, provide hinged and gasketed access door on bottom of unit to facilitate coil inspection.

D. Hot Water Heating Coil:

1. Coils will be provided separately from the box.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors or locate units above easily removable ceiling components. In no instance shall units be installed in inaccessible locations.

C. Support units individually from structure. Do not support from adjacent ductwork.

D. Connect to ductwork in accordance with Section 23 31 13.

E. Verify that electric power is available and of the correct characteristics.
F. Maintain a minimum of 18” clearance in front of VAV controller.

3.2 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation as indicated on equipment schedule.

END OF SECTION 23 36 00
SECTION 23 36 50 – LABORATORY AIRFLOW CONTROL SYSTEM

1. GENERAL

1.1 RELATED DOCUMENTS

1.2 SYSTEM DESCRIPTION

A. The laboratory airflow control system (LACS) shall consist of all components and wiring required to maintain proper laboratory airflow, pressurization, temperature, and fume hood average face velocity, and to implement an integrated system as specified herein and as shown on the Drawings.

B. The LACS shall control the airflow into and out of laboratory rooms. Points shown on Drawings shall be communicated with the Owner BMS system via a BACnet-over-IP communication interface using Room Manager software via a network PC, provided by the LACS. All required components to create seamless communication between the LACS and Owner system shall be included. The LACS shall accept adjustment of setpoints from the Owner system. Coordinate exact requirements with the Owner prior to submitting shop drawings. The Contractor shall verify that the LACS supplier and Controls Contractor provide fully integrated communication between the LACS and BMS.

C. The LACS shall control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator’s presence in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The LACS shall respond and adjust airflow at the fume hood within 1 second of sash movement.

D. The system shall include room controllers, fume hood controllers, supply and exhaust airflow control devices, reheat coils and valves, all associated low voltage wiring, and all necessary accessories to implement an integrated system as specified herein. System verification and documentation shall also be included.

E. Subject to compliance with requirements, all laboratory airflow control system components shall be products of a single manufacturer and be the responsibility of that manufacturer. The laboratory airflow control system shall be manufactured by Phoenix Controls Corporation, no equivalent.

1.3 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of LACS systems and shall be the manufacturer’s latest standard design that complies with the specification requirements.
B. Parts and labor warranty shall start on the date of substantial completion for a period of 3 years. Any materials or system performance problems shall be corrected by the manufacturer at no cost to the owner during the warranty period.

C. Supplier shall have an in-place support facility within 300 miles of the site with technical staff, spare parts inventory, and all necessary test and diagnostic equipment.

D. Installation as well as the startup, checkout and commissioning of the LACS shall be by full time employees of the control system manufacturer and shall be fully trained by the system manufacturer.

1.4 SUBMITTALS

A. Reference specification Section 23 05 00.

B. The submittal shall include:

1. Manufacturer's product data including all equipment components such as fume hood monitors, controllers, terminal devices, etc.
2. Shop drawings shall include system wiring diagrams with sequences of operation, schedule of air terminal devices with complete sizing data for each device, a system configuration diagram showing all controller types and locations, and a communications network schematic.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store equipment and materials inside and protected from weather.

B. Where control devices specified in this Section or on Drawings are indicated to be factory-mounted on equipment, arrange for shipping of control devices to unit manufacturer.

2. PRODUCTS

2.1 MANUFACTURERS

A. This specification is based on the Celeris-2 system by Phoenix Controls Corporation (no equivalent).

2.2 LABORATORY CONTROL SYSTEM - GENERAL

A. Each laboratory shall have a dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of 40 network controlled airflow devices.
B. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.

C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.

D. The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator’s presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.

E. The laboratory airflow control system shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.3" to 3.0" wc).

F. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. See Drawings for the offset values and relative pressurization between spaces. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as varying levels of occupancy at fume hoods or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.

G. The laboratory airflow control system shall maintain specific airflow (±5% of signal) with a minimum 16 to 1 turndown to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

2.3 FUME HOOD CONTROLS

A. Fume Hood Presence Sensors

1. A presence and motion sensor shall be provided to determine an operator’s presence in front of a hood by detecting the presence and/or motion of an operator, and to command the laboratory airflow control system from an in-use operating face velocity (80 fpm) to a standby face velocity (60 fpm) and vice versa.

   a. The sensor shall define a detection zone that extends approximately 20" from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within an adjustable time period (initially five seconds), it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within one second.
The sensor shall have a control circuit that adapts to its specific surroundings and adjusts automatically for inanimate objects placed within its detection zone. It shall map the area into memory and, after a period of five minutes, nullify the image of the inanimate object and return to a standby mode. When operators enter and leave the zone, the unit shall adjust automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall re-map the area automatically.

c. Wide area motion detectors (on the hood or room level) shall be unacceptable.

B. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash totally closed.

2.4 FUME HOOD MONITOR

A. The display screen shall be 3.2" color LCD resistive touch screen (240 x 320 RGB).

B. The display screen shall provide options for portrait or landscape orientation.

C. The touch screen shall support input configurations for fume hood operational parameters done at the touch panel and at a minimum including:

1. Sash dimensions
2. Hood ID
3. Hood Certification
4. Hood Occupancy Status
5. Stop watch/timer

D. Hood configuration for the following properties shall be viewable and editable from the touch display:

1. Sash dimensions
2. Hood ID
3. Hood Certification
4. Hood Occupancy Status
5. Stopwatch/timer

E. Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.

F. Flush mount or recess mount shall be installation options.

1. USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or corrosion.
2. A timer feature shall be provided to enable users to set specific time to time the duration for experiments and provide visual and audible alarms when the set time is expired.
G. Power: The device shall be powered by 24 VAC ± 15% at 10VA, 50/60 Hz.

H. Configuration

1. Configuration shall be performed from the touch display and/or manufacturer’s software tools.
2. The device shall be capable of being added to an existing LON communication network. The device shall display Fume hood performance data based on control logics embedded inside the valve controller.

I. Communication

1. The fume hood display unit shall connect to LON communication and link directly to a specific valve controller associated with the hood it is mounted to.
2. The device shall display fume hood performance data based on the valve controller performance and sash movements over LON.

J. Information display

1. The device shall have the ability to show when the fume hood face velocity is within the normal operating range, energy saving, hood certification, hood ID, timer, and hood occupancy status.
2. The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m3/h), liters per second (l/s), feet per minute (fpm), or meters per second (m/s).
3. The device shall have the ability to display system errors caused by the airflow valve or sash travel.
4. The device shall have the ability to notify users when the hood is due for recertification and shall provide a visible notification at the LCD display stating “Fume Hood Certification is due or expired.”

K. Alarms

1. The device shall have the ability to show alarms on the main screen using visual and audible alerts.
   a. The main screen background color shall change to flashing red with text stating the type of alarm.
   b. In alarm state, the enunciator shall remain active until the event that triggered the alarm is removed or fixed.
2. The device shall have the ability to show Diversity alarm.
   a. Diversity alarm shall be generated by the valve or from the BMS system.
   b. No audible tone shall be generated at the fume hood display.
3. The device shall have the ability to have customizable audible alarms levels and customizable mute duration.

   a. Users shall have the ability to change the volume of the alarm tone to low, medium, or high.
   b. The device shall have an Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
   c. The alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.

L. Energy conservation

1. The device shall have the ability to enable fume hood hibernation mode.

   a. When activated the exhaust flow through the fume hood goes to the minimum allowed by the exhaust valve when the sash is fully closed and no chemicals are present in the hood.
   b. The mode shall be initiated by a sequence including pressing on the touch display and a pushbutton on the fume hood monitor, external momentary switch input to the fume hood monitor, or a network command.
   c. When activated, the LCD display shall show “Hood in Hibernation,” and the exhaust valve shall move to its minimum position or shutoff position.
   d. Safety shall be built into the decommission option, whereby opening the fume hood sash shall automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood decommissioning shall be a point that can be integrated to the BMS system.

2. The device shall provide night time energy waste alarming to generate a visual and audible alarm to notify when the fume hood sash is open beyond its minimum flow position and the lights in the room are off.

3. When activated, the LCD display shall show “Energy Waste Lower Sash” and the audible alarm shall sound until the sash is closed.

4. The light levels at which the alarm is both initiated and cancelled shall be configurable.

5. The device shall provide sash energy waste alarming, which generates a visual and audible alarm to notify when the fume hood sash is open beyond a configurable set position and no one is in front of the fume hood.

   a. When activated, the LCD display shall show “Energy waste Lower Sash” and the audible alarm shall sound until the sash is closed.

2.5 AIRFLOW CONTROL DEVICES – GENERAL

A. The airflow control device shall be a venturi valve. Each venturi valve will have a factory mounted and piped precision differential pressure (DP) switch mounted across the pressure taps.
B. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

C. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1.

D. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

E. The airflow control device shall be constructed of one of the following three types:

1. Laboratory supply valves (LSVs) and general exhaust valves (GEVs) shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester or PPS (polyphenylene sulfide) composite. All LSVs shall be factory-insulated with closed cell insulation.

2. Fume exhaust valves (FEVs) shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.

F. Actuation

1. A UL 916 listed electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

2. Constant volume valves do not require actuators, unless required to maintain constant airflow.

G. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network.

H. The room-level control network shall utilize a LonTalk communications protocol.

I. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, temperature control, humidity control, and implement occupancy and emergency mode control schemes.
J. The laboratory airflow control systems shall have digital integration with the JCI BMS.

K. Certification

1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.

2. Each airflow control devices shall be marked with device-specific factory calibration data. At a minimum, it should include the tag number, serial number, model number, eight-point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

2.6 AIRFLOW CONTROL SOUND

A. Unless otherwise specified, the airflow control device shall not exceed the sound power levels in Paragraphs 2.5.D, 2.5.E, and 2.5.F.

B. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device’s maximum rated flow rate not to exceed 0.20 inches of water.

C. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.

D. Exhaust Airflow Control Device Sound Power Level

<table>
<thead>
<tr>
<th>Octave Band Number</th>
<th>Exhaust Sound Power Level in dB (re: 10⁻¹² watts)</th>
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</thead>
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### Exhaust Sound Power Level in dB (re: 10⁻¹² watts)

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### E. Supply Airflow Control Device Sound Power Level (Discharge)

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### F. Supply Airflow Control Device Sound Power Level (Radiated)

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### LABORATORY AIRFLOW CONTROL SYSTEM

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</table>

G. Discharge and Radiated sound power level data for all terminals shall be available and provided with submittals. The data shall be in accordance with the test procedure in ANSI/ASHRAE 130-1996 standard for ducted air terminal units and all data shall be obtained in a qualified, accredited and ANSI/ASHRAE approved testing laboratory.

### 2.7 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

A. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

B. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.

C. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no room-level controller shall be required.

D. The airflow control device shall use industry standard 24 Vac power.

E. The airflow control device shall have provisions to connect a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.

F. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control, occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:

1. Three universal inputs capable of accepting 0 to 10 Vdc, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
2. One digital input capable of accepting a dry contact or logic level signal input.
3. Two analog outputs capable of developing either a 0 to 10 Vdc or 4 to 20 mA linear control signal.
4. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 Vac/Vdc.

G. The airflow control device shall meet FCC Part 15 Subpart J Class A and be UL916 listed.
2.8 CONTROL FUNCTIONS

A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, pressurization, temperature, humidity control, as well as respond to occupancy and emergency control commands.

B. Pressurization Control

1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.

2. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.

3. The pressurization control algorithm shall consider both networked devices, as well as:

   a. Up to three non-networked devices providing a linear analog flow signal.
   b. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

4. Volumetric offset shall be the only acceptable means of controlling room pressurization.

5. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

C. Temperature Control

1. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the BMS, with the option of a local offset adjustment.

2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.

3. Temperature Sensors: Wall-mounted sensor with 10,000-ohm thermistor with an accuracy of +/- 2 Deg. C, temporary override switch, setpoint slider, test-and-balance switch, and 3.5-mm
communications jack. Communications jack shall provide access to all LACS setpoints and conditions.

D. Occupancy Control

1. The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state shall be set by the use of the local occupancy sensor. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The initial setting shall be set at 120 minutes.

E. Fume Hood Control

1. Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:

   a. Accept command inputs to regulate the flow accordingly and make this command value available to the BMS.
   b. Accept a sash position signal and make this value available to the BMS.
   c. Accept a Fume hood Presence Sensor signal to indicate user presence and make this signal available to the BMS.
   d. Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMS.
   e. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication. Send alarm signals to BMS.

2. The fume hood airflow control device shall respond to changes in user presence within one second, in order to provide a constant 80-feet-per-minute face velocity when the fume hood is in use.

F. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BMS communications are carried out reliably. Each laboratory space or pressurization zone shall be its own subnet. Commercially available routers shall be used to provide this isolation.

G. The laboratory airflow control system shall support at least 20 networked devices in each pressurized zone.

H. All points shall be available through the interface to the BMS for trending, archiving, graphics, alarm notification and status reports. Laboratory airflow control system performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.
I. Refer to the BMS specification and Drawings for the required input/output summary for the necessary points to be monitored and/or controlled.

2.9 ROOM INTEGRATOR INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The LACS network shall have the capability of digitally interfacing with the BMS using room integrators that seamlessly integrate critical airflow control devices into the BMS. The required software interface drivers will be provided by the LACS supplier to allow room by room (2 channels) integration of up to 40 devices per room integrator.

B. The room monitor integrators purpose is providing protocol translation and data integration between the company's environmental control systems to BACnet compatible BMS systems. All room-level points shall be available to the BMS for monitoring or trending as shown in Table 1. The LACS server shall maintain a cache of all points to be monitored by the BMS. The room-level airflow control devices shall update this cache continually.

C. The room integrators also perform bidirectional translation between room-level devices using the LonWorks protocol and the BAS utilizing BACnet over IP or MS/TP to manage read requests and write commands.

D. The room integrators includes a web server with the features available through web pages for troubleshooting and commissioning devices in the space. A.) Diagnostic displays are used by technicians to troubleshoot the room level network and perform these task remotely when using BACnet over IP. B.) Lab verification features allow field acceptance testing for one pressurization zone or space at a time. Full space testing, min/max airflows, Occupied/Unoccupied set points can be captured for readings for reporting and archival. C.) Test and balance (TAB) function allow 3rd party verification to measure all airflows to ensure valves are performing per the design. Full heating and cooling can be checked along with hot water reheat and AHU systems checking. This can be saved in a .csv file for TAB reporting.

E. Up to 20 high-speed Celeris devices or 20 low-speed LON devices per network channels for each of the 2 available network channels per room integrator.

F. Network switches 10/100, located in equip. closets or spaces outside the labs, will be provided by the LACS to allow connection to the BMS to integrate all lab network points. The maximum length of CAT 5 cable will 500 ft.

G. Room Manager software and an a network PC will be provided by the LACS to allow a single static IP address to integrate with the JCI BMS system.

3. EXECUTION

3.1 INSTALLATION

A. Install all system components in accordance with manufacturer recommendations and requirements.
B. Coordinate all work with Division 26 Contractor and other trades.

C. Contractor and LACS Supplier shall coordinate the integration of the BMS and LACS systems. See Drawings for more information.

D. Install the interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the LACS supplier.

E. Provide single or 5 output 98va per circuit power supplies and install 24 Vac transformer with secondary circuit breaker suitable for NEC Class II wiring wherever required for a complete, operational system. At minimum, provide one transformer for each room controller and/or airflow control device actuator. Coordinate 120V power requirements and locations with Div. 26 contractor.

F. Install all required room monitors/controllers and network switches in accessible locations outside the spaces that they serve in BMS enclosures and/or their own enclosures.

G. Provide and install all required cables. Terminate and connect all cables as required. Utilize cables specifically recommended by the laboratory airflow controls supplier.

H. Install all airflow control devices in the ductwork and connect all airflow control valve linkages. The use of screws or rivets to connect ductwork to airflow control devices is not allowed unless expressly allowed by the LACS manufacturer and approved by the Engineer or Owner’s Representative.

I. Provide and install all reheat coils and transitions.

J. Provide and install insulation as required. Insulate all exposed areas of the supply air duct system.

3.2 SYSTEM START-UP AND TRAINING

A. Contractor and LACS Supplier shall coordinate all start-up and training with Owner’s Commissioning Agent.

B. System start-up shall be provided by a factory-authorized representative of the LACS manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BMS.

C. Notify Owner’s Representative a minimum of 14 days prior to system start-up.

D. Testing, adjusting, balancing of the fume hood face velocity, supply, and general exhaust flows will be done by the TAB contractor. The laboratory airflow control system supplier shall coordinate testing, adjusting and balancing of the laboratory airflow control system with the TAB contractor.

E. The LACS supplier shall furnish a minimum of eight hours of Owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control
components, verification of initial fume hood monitor calibration, general procedures for verifying
airflows of air valves and general troubleshooting procedures.

F. In addition to the 8 hour job-specific training, the owner has requested an in-depth two-day
training course on the WorkBench Software be furnished to a minimum of 2 UM Hospital
employees. The course is intended to increase the comfort level with the Phoenix system as the
owner has not had previous experience with the system.

G. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall
be provided for each training attendee.

END OF SECTION 23 36 50
SECTION 23 37 00 - AIR OUTLETS AND INLETS

1. GENERAL

1.1 SECTION INCLUDES

A. Diffusers.

B. Registers/grilles.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

2. Test and rate louver performance in accordance with AMCA 500. Submit AMCA certification with submittal.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

1. Record actual locations of valves.

F. Delivery, storage, and handling.

2. PRODUCTS

2.1 CEILING DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.

2.2 WALL REGISTERS AND GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with adjustable elbow. Install maximum length of 5’ of flexible duct upstream of each diffuser and grille, unless otherwise noted. See details on Drawings. All connections shall be air tight.

D. In laboratories with ventilated workstations, position diffusers so that airflow is directed parallel to the front of the workstation, not perpendicular to it.

E. Where diffusers are located near fume hoods, canopy hoods, biological safety cabinets, or other devices which are sensitive to air turbulence, install diffuser to direct airflow parallel to the front face of the device (i.e. not directed at device).
F. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly. Where a balancing damper has been omitted from drawing, consult engineer.

G. Paint ductwork visible behind air outlets and inlets matte black.

H. Provide return air sound boot on grilles as shown on drawings.

I. Where slot diffusers or linear diffusers are located near perimeter windows, adjust at least one slot to direct air toward window.

END OF SECTION 23 37 00
SECTION 23 52 00 – HEATING BOILERS

1. GENERAL

1.1 SECTION INCLUDES

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, firetube duplex stainless steel ultra-high efficiency condensing boilers, trim and accessories for generating hot water.

1.2 DESCRIPTION OF WORK:

1. Extent of boiler work required by this section is indicated on drawings and schedules, and by requirements of this section.
2. Refer to other Division 23 sections for piping, specialties, water treatment, pumps, breechings, temperature controls, etc., required external to boilers for installation; not work of this section.
3. Electrical Work: Refer to Division-23 section "Electrical Provisions of Mechanical Work" for requirements.
4. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 26:
   a. Furnish to Electrical Installer, burner emergency shutoff switch.
   b. Provide control wiring between boiler control panel and thermostats, aquastats, pressurestats, safeties, or any other control device related to the boilers.
   c. Provide controls and electrical devices as specified in this section.
5. Refer to Division-26 sections for other electrical work including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.3 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Manufacturer Qualifications: Firms regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than twenty-five (25) years. The manufacturer must be privately owned and headquartered in North America. The specifying engineer, contractor and end customer must have the option to visit the factory during the manufacture of the boilers and be able to witness test fire and other relevant procedures.
2. Aftermarket Support and Service: The manufacturer shall have a factory authorized service training program, where boiler technicians can attend a training class and obtain certification to perform start-up, maintenance and basic troubleshooting specific to the product line.
3. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

4. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers”, for a maximum allowable working pressure of 160 PSIG.

5. CSD-1 Compliance: The boiler shall comply with ASME Controls and Safety Devices for Automatically Fired Boilers (CSD-1).

6. ASHRAE/IESNA 90.1-2010 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers - Minimum Efficiency Requirements.”

7. UL Compliance: Boilers must be tested for compliance with UL 795, “Commercial-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by ETL.

8. AHRI Compliance: Boilers shall be tested and rated according to the BTS-2000 test standard and verified by AHRI.

9. NOx Emissions Compliance: Boiler shall be tested for compliance with SCAQMD and TCEQ.

10. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer’s current catalog.

11. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.

12. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.

13. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.

14. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

B. References.

1. ASME Section IV
2. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers
3. CSD-1, Controls and Safety Devices
4. XL GAPS
5. NEC, National Electric Code
6. UL-795 7th Edition
7. AHRI, BTS-2000
8. ASHRAE 90.1-2010

C. Submittals.

1. Product Data: Include performance data, operating characteristics, technical product data, rated capacities of selected model, weights (shipping, installed and operating), installation and start-up instructions, and furnished accessory information.
2. Shop Drawings: For boiler, standard boiler trim and accessories.
HEATING BOILERS

a. End Assembly Drawing: Detail overall dimensions, connection sizes, connection locations, and clearance requirements.
b. Wiring Diagrams: Detail electrical requirements for the boiler including ladder type wiring diagrams for power, interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.


4. Thermal efficiency curves: Submit thermal efficiency curves for a minimum of 5 input rates between and including minimum and maximum rated capacities, for return water temperatures ranging from 80°F to 180°F.

5. Water side pressure drop curve.

6. Flue gas temperature curves: Submit flue gas temperature curves for minimum and maximum boiler capacity, for return water temperatures ranging from 80°F to 160°F.

   a. If submitted flue gas temperatures, minimum or maximum inputs are different from that of the basis of design manufacturer and model, the manufacturer shall be responsible for draft calculations and reselection of the flue gas exhaust system.

7. Source quality-control test reports.

8. Field quality-control test reports: Start-up by a factory authorized service company.

9. Operation and Maintenance Data: Data to be included in Installation and Operation Manual.

10. Warranty: Standard warranty specified in this Section.

D. Operation and maintenance manuals.

E. Project record documents.

1. Complete parts list
2. Certified startup and combustion test record

F. Delivery, storage, and handling.

1. Handle boiler components and equipment carefully to prevent damage, breaking, and scoring. Do not install damaged components; replace with new.
2. Store boiler sections and equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
3. Comply with manufacturer's rigging and moving instructions for unloading boilers, and moving them to final location.

G. Regulatory requirements
H. Coordination:

1. Mechanical contractor shall coordinate the size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete reinforcement and formwork requirements are specified in Division 03.

I. Warranty:

1. Standard Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

   a. Warranty Period for the Pressure Vessel and Heat Exchanger: The boiler manufacturer shall warranty against failure due to thermal shock, flue gas condensate corrosion, and/or defective material or workmanship for a period of 10 years, non-prorated, from the date of shipment from the factory provided the boiler is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.

   b. Warranty Period for all other components: The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within eighteen (18) months of shipment from the factory or twelve (12) months from start-up, whichever comes first.

2. PRODUCTS

2.1 BOILERS

A. Manufacturers:

1. This specification is based on the Endura series boilers as manufactured by Fulton Heating Solutions, Inc. Equivalent units and manufacturers must meet all performance criteria, and will be considered upon prior approval.

2. Approved Equivalent Manufacturers:

   a. Camus Advantage
   b. Laars
   c. Aerco
   d. Viessmann
   e. Or Approved Equal. ¹

3. Basis-of-Design Product: Subject to compliance with requirements, provide Fulton Heating Solutions, Inc.; Endura model duplex stainless steel firetube condensing boiler.
4. The boiler manufacturer shall have the capability to construct an engineered hydronic system, skid mounted, for the above referenced boilers incorporating single point electrical, supply water, return water, fresh water make up, fuel, and drain. The boiler manufacturer shall have the engineering capabilities for all aspects of the mechanical, electrical and control design aspects of the skid mounted system.

B. Construction:

1. Description: Factory-fabricated, -assembled, and -pressure tested, duplex stainless steel firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including flue gas vent; combustion air intake connections, water supply, water return, condensate drain, and controls. The boiler, burner and controls shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping. Closed-loop water heating service only.

2. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where flue gases transfer sensible and latent heat to the hydronic fluid. The heat exchanger shall be a three-pass firetube design constructed using only duplex alloys of stainless steel.

   a. The boiler shall be a firetube design, such that all combustion chamber components are within water-backed areas. Watertube boilers will not be accepted.
   b. Furnace: First pass of the combustion chamber shall be constructed of duplex alloy stainless steel with a minimum wall thickness of 0.25" and a minimum bottom head thickness of 0.625".
   c. Firetubes: Second and third passes of the combustion chamber shall be constructed of duplex alloys of stainless steel having a minimum wall thickness of 0.109".
   d. Furnace to tube connections shall be constructed with low weld intensity, a tube to tube minimum spacing of 2" center to center, minimum 5/8" tube to tube ligament, and shall not contain any overlapping welds.
   e. Heat exchange capability shall be maximized within the heat exchanger via the use of corrugated firetube technology. The corrugation process shall not remove any material from the tubes. Aluminum heat transfer enhancements are dissimilar metals and are unacceptable.
   f. Material: The heat exchanger shall have the following material characteristics and properties:

      1) The metallic crystalline lattice microstructure shall contain approximately equal amounts of body center cubic (BCC) and face centered cubic (FCC) structures to offer high resistance to intergranular corrosion.
      2) A minimum Pitting Resistance Equivalent Number (PREN) of 26.
      3) A minimum Yield Strength of 65 ksi at 0.2% plastic strain.
      4) A minimum Ultimate Tensile Strength of 94 ksi.
      5) To minimize stresses caused by uneven expansion and contraction, the Coefficient of Thermal Expansion at 212°F shall not be less than 7.0 in/in °F 10⁻⁶ and shall not be greater than 7.5 in/in °F 10⁻⁶.
6) To increase resistance to pitting and crevice corrosion, the Chromium content shall not be less than 21% by mass.
7) For high mechanical strength, the Nitrogen content shall not be less than 0.17% by mass.
8) Boilers with heat exchangers constructed of austenitic stainless steels, such as 316L or 304, and ferritic stainless steels, such as 439, are unacceptable.
9) Boilers with heat exchangers constructed of cast aluminum, mild steel, cast iron or copper finned tube materials are unacceptable.

3. Pressure Vessel: Design and construction shall be in accordance with Section IV of the ASME Code for heating boilers.
   a. The shell shall be minimum 0.3125" thick steel, SA-790 or SA-516 Grade 70.
   b. The top head shall be a minimum 0.375" thick steel, SA-790 or SA-516 Grade 70.
   c. The water side of the pressure vessel shall be a counter-flow design with internal water-baffling plates.
   d. The boiler return and supply water connections shall be 4" 150# ANSI flanged. The water connections shall not be designed to support an external structural load from the piping system.
   e. The water volume of the boiler shall not be less than EDR-2000: 102 Gallons.
   1) For boilers with a lower water volume, the boiler manufacturer shall provide a buffer tank and all associated buffer tank ancillaries to make equivalent to the total volume of the design basis.
   f. The maximum water pressure drop across the boiler inlet and outlet connections, shall not exceed: 1.6 PSID at 200 GPM.

   a. Burner Head: Shall be a woven fiber premix design.
   b. Excess Air: The burner shall operate at no greater than 7.0% excess O₂ over the entire turndown range. Due to significant reductions in combustion efficiency at high levels of excess O₂, boilers exceeding 7.0% excess O₂ at any operating condition shall not be accepted.
   c. Emissions: When operating on natural gas, the boiler shall maintain a NOx level of <20 ppm, and CO emissions less than 50 ppm, over the complete combustion range at a 3% O₂ correction.

5. Blower: Variable speed, non sparking, hardened aluminum impeller centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.
a. Motor: Brushless DC variable speed motor with hall effect sensor feedback; internal electronic commutation controller with built in speed control and protection features; long life, sealed, ball bearing with high temperature grease.
b. Variable speed blower: PWM signal input with tachometer output.

6. Main Fuel Train:
   a. The boiler shall have a pre-mix combustion system, capable of operating at a minimum 4" W.C. incoming natural gas pressure while simultaneously achieving emissions performance, full modulation, and full rated input capacity. Maximum natural gas pressure allowed to the inlet of the fuel train shall be no less than 28" W.C.
   b. A factory mounted main fuel train shall be supplied. The fuel train shall be fully assembled complete with high and low gas pressure switches, wired, and installed on the boiler and shall comply with CSD-1 code. The fuel train components shall be enclosed within the boiler cabinet.
   c. A lock up regulator upstream of the fuel train shall be furnished by the boiler manufacturer as a standard component integral to the boiler cabinet. Factory test fire of the boiler with the provided lock up regulator is required.
   d. Standard CSD-1 fuel train shall comply with IRI, which has been replaced by XL GAPS.

7. Ignition: Direct spark ignition with transformer. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer. Flame rods are not accepted.

8. Boiler Enclosure:
   a. Sealed Cabinet: Jacketed steel enclosure with left hinged full height front access door, fully removable latching access panels, gasketed seams to maintain sealed combustion, mounted on a steel skid with steel plate decking.
   b. Control Enclosure: NEMA 250, Type 1.
   c. Finish: Internally and externally primed and painted finish.
   d. Combustion Air: Drawn from the inside of the sealed cabinet, preheating the combustion air.

9. Rigging and Placement: The boiler shall include lifting eyes and fork hole accessibility for rigging.

10. Exhaust Manifold: Shall be constructed of stainless steel, with an area for the collection and disposal of flue gas condensate. The exhaust outlet connection shall allow for immediate vertical rise off the boiler without requiring an elbow or tee.

11. Characteristics and Capacities:
   a. Heating Medium: Closed loop hot water with up to 50% propylene or ethylene glycol by volume. Standard capacities shall be based on 100% water.
   c. Safety Relief Valve Setting: 125 psig.
d. Minimum Return Water Temperature: No minimum temperature required.
e. Maximum Allowable Water Temperature: 210°F.
f. Minimum Water Flow Rate: No minimum flow rate required to protect the heat exchanger.
g. Maximum Water Flow Rate: No maximum flow rate requirement.
h. Minimum Delta-T: No minimum delta-T required.
i. Maximum Delta-T: 100°F
j. Minimum Side Clearance: Shall not exceed 1” between any number of boilers.
k. Jacket Losses: External convection and radiation heat losses to the boiler room from the boiler shall comply with IAW ASHRAE 103-2007, and shall not exceed 0.2% of the rated boiler input at maximum capacity.

12. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard. The certified thermal efficiency for natural gas firing shall not be less than: 93.7%.

13. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary-secondary arrangements shall not be required to protect the boiler from thermal shock. Boilers requiring the use of flow switches or primary-secondary piping arrangements are unacceptable.

14. The dimensions of the boiler shall not be more than (Height x Width x Depth) 80” x 34” x 61”.

15. The dry weight of the boiler shall not be less than: 2,360 lbs.

a. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer’s standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer’s standard commercial product, shall be included in the equipment being furnished.

C. TRIM

1. Safety Relief Valve: ASME rated.
2. Pressure and Temperature Gauge: Minimum 3-1/2” diameter, combination pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

a. Mounted in the field in the boiler supply water piping prior to the first isolation valve by the boiler installer.

4. Flue Gas Condensate Drain Trap: A flue gas condensate drain trap shall be provided to prevent positive pressure exhaust gases from entering the boiler room.
5. Condensate drain PH Neutralization kit: A neutralization kit shall be provided to limit corrosive condensate entering the sanitary sewer system.
D. CONTROLS

1. The boiler electrical control panel shall include the following devices and features:
   a. 7” color touch screen control display factory mounted on the front cabinet panel door.
      1) The control display shall serve as a user interface for programming parameters, boiler control and monitoring; and shall feature a screen saver, boiler status, configuration, history and diagnostics.
   b. The boiler control panel shall be constructed in a UL 508 approved panel shop.
   c. 24 VAC control transformer.
   d. Control relay for 120 VAC motorized isolation valve control.
   e. The flame safeguard control on the boiler shall be integrated with temperature control and lead/lag sequencing modular boiler plant functionality.
   f. All controls are to be cabinet, vessel or panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to UL requirements.

2. Burner Operating Controls: To maintain safe operating conditions, factory mounted and wired burner safety controls limit burner operation:
   a. High Limit: A single UL 353 temperature probe shall function as a dual-element outlet temperature sensor and shall comply with CSD-1 CW-400 requirements for 2 independent temperature control devices.
      1) High limit sensor shall be NTC resistive 10KOhm +/- 1% at 77°F. Sensor shall have brass material bulb with 1.181 +/- 0.015” insertion and 0.370 +/- 0.005” bulb diameter.
      2) Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
   b. Low-Water Cut Off: Electronic probe type mounted in the pressure vessel shall prevent burner operation on low water alarm.
   c. Air Safety Switch: Prevent operation unless sufficient combustion air is proven.
   d. High Condensate Probe: Prevent operation in the event of a blocked condensate drain.
   e. Blocked Exhaust: Prevent operation in the event of a blocked flue gas exhaust stack.

3. Boiler Operating Controls and Features:
   a. Proportional Integral Derivative (PID) temperature load control capability for up to two loops, central heat and domestic hot water.
   b. Operating temperature limit for automatic start and stop.
c. Flue gas exhaust temperature monitoring.
d. Return water temperature monitoring.
e. Time of day display.
f. Customizable boiler name display.
g. Alarm history for 15 most recent alarms including equipment status at time of lockout.
h. Password protection options.
i. Indirect domestic hot water priority.
j. Outdoor air temperature (OAT) reset controls with warm weather shutdown:

1) OAT reset shall automatically adjust the setpoint according to changes in the outdoor temperature.
2) The boiler manufacturer shall provide an OAT sensor and module.
3) The sensor shall have +/- 1.5°F accuracy at 70°F, field installed in an outdoor area not exposed to direct sunlight or the exhaust of other mechanical equipment, and field wired to the master boiler.
4) The control shall be field programmed with the outdoor reset schedule.
5) The control shall have the ability to disable the entire hydronic boiler system on warm weather shutdown based on a programmable OAT.

4. Sequencing Control of Modular Boiler Plants: Sequencing capabilities (lead/lag) shall be integral to the boiler controller for up to 8 boilers installed in the same hydronic loop and shall not require an external panel.

a. The boiler manufacturer shall provide a supply water header temperature sensor.

1) The sensor shall be NTC resistive 10KOhm +/- 1% at 77°F, field installed in the common supply water piping, and field wired to the master boiler.

b. One (1) boiler in the system shall be field programmed as the master and subsequent boilers will be programmed as lag units.

c. Sequence of Operation:

1) Upon call for heat and demand in the system, a boiler will be enabled at low fire and will modulate according to demand and PID settings up to the base load common value. The base load common shall be field adjustable with a default setting of 40%.

2) If the heating load exceeds the output at the base load common firing rate, the next boiler in the sequence will be enabled at low fire. Modular boilers will modulate up and down in parallel as a cohesive unit with infinite modulation points to meet heating load requirements.

3) This process continues until all available boilers are enabled, at which point they are released to modulate up to full fire if required.

4) As the load decreases, the boilers will be sequentially disabled.

5) Boiler sequence order shall be rotated on a programmable number of run hours.
6) A boiler in lockout alarm shall be automatically removed from the sequence order.

7) Lag boilers shall default to local control if the master boiler is fully powered off or removed.

8) Each individual boiler shall enable and disable a water circulation control device. The enable of the device, for example a motorized isolation valve or boiler circulator, will be simultaneous with the heat demand for that boiler. The disable of each device will be based on a programmable time delay when the heat demand is no longer present. In variable primary arrangements, the control shall hold the lead boiler isolation valve open at all times.

d. Coordinate sequence of operations with temperature controls and contractor to ensure all devices shown on controls drawings are being provided and operational responsibility (BMS/boiler controller) of sequence.

5. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms.

a. Hardwired Contacts:

1) Monitoring: Boiler Status, Burner Demand, General Alarm, Firing Rate.
2) Control with Factory Installed Jumper: Safety Interlock for External Device, Remote Boiler Enable, Remote Lead/Lag Enable, Emergency Stop (E-Stop)
3) Remote Setpoint Signal: 4-20 mA.

b. Communication Protocol: A communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.

1) The boilers will communicate with each other and the Building Automation System via a daisy chain addressed Modbus network. Field wiring between nodes shall be twisted pair low voltage with shielded ground.
2) A BACnet MSTP and IP protocol communication gateway shall be provided. The BACnet gateway is field installed on the MASTER boiler. Lag boilers shall not require a dedicated BACnet gateway for the BAS to monitor status. The BAS shall only be required to communicate through the MASTER boiler. A communication point mapping list shall be provided.

E. Electrical Power:

1. Single-Point Field Power Connection: Factory-installed and factory-wired switches, transformers, control and safety devices and other devices shall provide a single-point field power connection to the boiler.
2. Electrical Characteristics:
HEATING BOILERS

F. Venting:

1. The boiler shall be capable of operating with a stack effect not exceeding -0.04” W.C. and a combined air intake and exhaust venting pressure drop not exceeding +1.50” W.C.

2. Combustion Air Intake: It shall be acceptable to either direct vent the boiler using sealed combustion by drawing combustion air in from the outdoors or by drawing air from the mechanical space itself.

   a. Sealed Combustion: Schedule 40 PVC pipe or smooth-walled galvanized steel, vent termination with 1/2” x 1/2” mesh bird screen.
   b. Mechanical Space: Adequate combustion air and ventilation shall be supplied to the boiler room in accordance with boiler manufacturer requirements and local codes.

3. Flue Gas Exhaust: The flue gas exhaust stack shall be AL 29-4C or 316L stainless steel, listed and labeled to UL-1738 / C-UL S636 for use with Category II/IV appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting.

   a. See specification section 23 51 00: “Breechings, Chimneys, and Stacks.”

4. The boiler shall be capable of common exhaust and intake venting. The draft system shall be designed to prevent the backflow of exhaust gases through idle boilers.

5. Condensate drain piping must be galvanized, stainless steel, or Schedule 40 CPVC. Copper, carbon steel, or PVC pipe materials are not accepted.

G. Source Quality Control:

1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

2. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

3. EXECUTION

3.1 EXAMINATION
1. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
   a. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

2. Examine mechanical spaces for suitable conditions where boilers will be installed.
3. Proceed with installation only after satisfactory conditions have been verified.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base, minimum 3.5 inches high. Concrete base is specified in Division 23 Section “Common Work Results for HVAC,” and concrete materials and installation requirements are specified in Division 03.

B. Install gas-fired boilers according to NFPA 54. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturer’s installation requirements.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with the boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

C. Connect gas piping to boiler gas train inlet with isolation valve and union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

D. Connect hot water supply and return water connections with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to the nearest floor drain or local equivalent approved by local code.
F. Install piping from flue gas condensate drain connection to the condensate drain trap and to the nearest floor drain.

G. Boiler Venting:
   1. Install flue venting and combustion air-intake.
   2. Connect to boiler connections, flue size and type as recommended by the manufacturer.

H. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

I. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables.”

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. After boiler installation is completed, the manufacturer shall provide the services of a field representative to inspect components, assemblies, and equipment installations, including connections and provide startup of the boiler and training to the operator.
   2. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.

B. Tests and inspections:
   1. Perform installation and startup checks according to manufacturer’s written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of startup, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other than normal occupancy hours for this purpose.
HEATING BOILERS

END OF SECTION 23 52 00
SECTION 23 64 23 – AIR-COOLED WATER CHILLERS

1. GENERAL

1.1 SECTION INCLUDES

A. Packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. ARI Certification: Certify chiller according to ARI 590 certification program.
2. ARI Rating: Rate water chiller performance according to requirements in ARI 506/110, "Water Chilling Packages Using the Vapor Compression Cycle."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

B. Performance requirements.

1. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

C. References.

D. Submittals.

1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

   a. Performance at ARI standard conditions and at conditions indicated.
   b. Performance at ARI standard unloading conditions.
   c. Minimum evaporator flow rate.
   d. Refrigerant capacity of water chiller.
   e. Oil capacity of water chiller.
   f. Fluid capacity of evaporator.
   g. Characteristics of safety relief valves.
   h. Minimum entering condenser-air temperature
   i. Performance at varying capacity with constant design entering condenser-air temperature. Repeat performance at varying capacity for different entering condenser-air temperatures from design to minimum in 10 deg F increments.
2. Shop Drawings: Complete set of manufacturer’s prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
   a. Assembled unit dimensions.
   b. Weight and load distribution.
   c. Required clearances for maintenance and operation.
   d. Size and location of piping and wiring connections.
   e. Wiring Diagrams: For power, signal, and control wiring.

3. Warranty: Sample of special warranty.

E. Operation and maintenance manuals.

F. Project record documents.
   1. Source quality-control test reports.
   2. Startup service reports.
   3. Warranty.

G. Delivery, storage, and handling.
   1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

H. Regulatory requirements.
   1. The boiler vessel shall be constructed in accordance with Section IV of the ASME Boiler and Pressure Vessel Code requirements, “H” stamped and registered with the National Board of Boiler and Pressure Vessels.
   2. The entire hot water boiler shall be U.L. Listed.

I. Coordination
   1. Coordinate sizes and locations of concrete bases with actual equipment provided.
   2. Piping roughing-in requirements.
   3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
   4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

J. Warranty.
   1. Products included in this specification section shall have an extended 2 year warranty. Refer to paragraph 12.2.2.1.1 in Specification Section 00 73 00 – Supplementary Conditions for more information.
2. PRODUCTS

2.1 PACKAGED AIR-COOLED WATER CHILLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product.
   a. Trane.
   b. JCI / York
   c. Daikin Applied

2. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

3. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.

4. Cabinet:
   a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
   b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
   c. Casing: Galvanized steel.
   d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 1000 hour salt-spray test according to ASTM B 117.
   e. Compressor and Motor: The unit shall be equipped with four hermetic, direct-drive, 3600 rpm 60 Hz suction gas-cooled scroll compressors. The design shall have only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency. Overload protection shall be internal to compressors. Each compressor shall include: centrifugal oil pump, oil level sight glass, and oil charging valve. Each compressor shall have compressor heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
   f. Refrigeration:
      1) Refrigerant: R-410a. Classified as Safety Group A1 according to ASHRAE 34.
      2) Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3) Refrigerant Circuits: The unit shall have dual refrigerant circuits. Each circuit shall have a scroll compressor piped in parallel with a passive oil management system. The passive oil management system shall maintain proper oil levels within the compressor and have no moving parts. Each refrigerant circuit shall include a filter drier, electronic expansion valve, liquid line and discharge service valves. Capacity modulation shall be achieved by turning compressors on and off. The unit shall have four capacity stages.

5. Evaporator:
   a. Brazed Plate:
      1) Direct-expansion, single-pass, brazed-plate design.
      2) Type 316 stainless-steel construction with copper as the braze material.
      3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      4) 430 psig refrigerant side working pressure.
      5) 150 psig water side working pressure.
      6) Evaporator shall be tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure.
      7) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
      8) Water side strainer and flowswitch shall be factory installed.
      9) Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.

6. Air-Cooled Condenser:
   a. Plate-fin coil with integral subcooling on each circuit, rated at 650 psig. Condensers shall be factory proof and leak tested at 715 psig.
      1) Construct coils of copper tubes mechanically bonded to aluminum fins.
         a) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
      b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
      c. Fan Motors: Three-phase condenser fan motors with permanently lubricated ball bearings and external thermal overload protection shall be provided.
         1) Provide variable speed drive on the first fan of each circuit to allow the unit to start and operate with ambient temperatures between 0 deg F and 125 deg F.
d. Fan Guards: Steel safety guards with corrosion-resistant coating.

7. Electrical Power:
   a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
   b. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key.
   c. Wiring shall be numbered and color-coded to match wiring diagram.
   d. Install factory wiring outside of enclosure in a raceway.
   e. Field power interface shall be to wire lugs NEMA KS 1, heavy-duty, nonfused disconnect switch.
   f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      1) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   g. Provide each motor with overcurrent protection.
   h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
   i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
   j. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
      1) Power unit-mounted controls where indicated.
   k. Control Relays: Auxiliary and adjustable time-delay relays.
      1) Indicate the following for water chiller electrical power supply:
         a) Current, phase to phase, for all three phases.
         b) Voltage, phase to phase and phase to neutral for all three phases.
         c) Three-phase real power (kilowatts).
         d) Three-phase reactive power (kilovolt amperes reactive).
         e) Power factor.
         f) Running log of total power versus time (kilowatt hours).
         g) Fault log, with time and date of each.
         h) <Insert features>.

8. Controls:
   a. Stand-alone, microprocessor based.
b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

1) Verify availability of items in list below; status displays may vary depending on unit size.
2) Date and time.
3) Operating or alarm status.
4) Operating hours.
5) Outside-air temperature if required for chilled-water reset.
6) Temperature and pressure of operating set points.
7) Entering and leaving temperatures of chilled water.
8) Refrigerant pressures in evaporator and condenser.
9) Saturation temperature in evaporator and condenser.
10) No cooling load condition.
11) Elapsed time meter (compressor run status).
12) Pump status.
13) Antirecycling timer status.
14) Percent of maximum motor amperage.
15) Current-limit set point.
16) Number of compressor starts.

d. Control Functions:

1) Verify availability of items in list below; functions may vary depending on unit size.
2) Manual or automatic startup and shutdown time schedule.
3) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water temperature.
4) Current limit and demand limit.
5) External water chiller emergency stop.
6) Antirecycling timer.
7) Automatic lead-lag switching.

e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1) Verify availability of items in list below; conditions may vary depending on unit size.
2) Low evaporator pressure or high condenser pressure.
3) Low chilled-water temperature.
4) Refrigerant high pressure.
5) High or low oil pressure.
6) High oil temperature.
7) Loss of chilled-water flow.
8) Control device failure.

f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.

1) Hardwired Points:
   a) Monitoring: On/off status.
   b) Control: On/off operation, chilled-water discharge temperature set-point adjustment.

2) ASHRAE 135 (BACnet) communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

9. Insulation:
   a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.

   1) Thickness: 3/4 inch.
   2) Factory-applied insulation over cold surfaces of water chiller components.

   a) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.

   3) Apply protective coating to exposed surfaces of insulation.

10. Accessories:

   1) Factory-furnished, chilled water flow switches for field installation.
   2) Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
   3) Factory-furnished molded elastomeric isolators for field installation.


12. Source quality control:

   a. Perform functional test of water chillers before shipping.
   b. Factory performance test water chillers, before shipping, according to ARI 506/110, "Water Chilling Packages Using the Vapor Compression Cycle."
c. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

3. EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine rough-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Maintain manufacturer’s recommended clearances for service and maintenance.

C. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

D. Install separate devices furnished by manufacturer and not factory installed.

3.3 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems

B. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to chiller to allow service and maintenance.
D. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, and drain connection with valve.

3.4 STARTUP SERVICE

A. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
7. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

C. Prepare a written startup report that records results of tests and inspections.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain water chillers.

END OF SECTION 23 64 23
SECTION 23 73 13 - PACKAGED AIR HANDLING UNITS

1. GENERAL

1.1 SECTION INCLUDES

A. Packaged air handling units.

B. Drain pans.

C. Heating coils.

D. Filter sections.

E. Cooling coils.

F. Humidifiers.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

1.3 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.4 EXTRA MATERIALS

A. Provide one extra set of fan belts and filters for each unit scheduled.

2. PRODUCTS
2.1 GENERAL DESCRIPTION

A. The Contractor shall furnish and install the indoor packaged air handling unit(s) as shown and scheduled on the plans. The units shall be installed in strict accordance with the specifications. All units shall be complete with fan section(s), coil section(s) and all accessories specified.

B. Configuration: As scheduled.

C. Performance Base: 1150 ft altitude conditions.

D. Fabrication: Conform to AMCA 99 and ARI 430.

2.2 CASING (DOUBLE WALL UNITS)

A. Unit manufacturer shall ship unit in segments as specified by the contractor for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

B. Under 55F supply air temperature and design conditions on the exterior of the unit of 81F dry bulb and 73F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.

C. Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8-inch w.g., whichever is less, and shall not exceed 0.0042 per inch of panel span (L/240).

D. Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.

E. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

F. Traction enhancements shall be applied to the unit floor to improve the walking surface in those unit sections where the floor is fully accessible, and not impeded by internal structural or functional features.
2.3 ACCESS DOORS

A. Access doors shall be 2-inch double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.

B. All doors shall be provided with a thermal break construction of door panel and door frame.

C. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.

D. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.

E. Handle hardware shall be designed to prevent unintended closure.

F. Access doors shall be hinged and removable without the use of specialized tools to allow.

G. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions.

H. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.

I. All doors shall be a 60-inch high when sufficient unit height is available, or the maximum height allowed by the unit height.

J. Multiple door handles shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit.

K. A shatterproof window shall be provided in access doors where indicated on the plans. Windows are not required no access doors serving filter sections.

2.4 PRIMARY DRAIN PANS

A. All cooling coil and humidifier sections shall be provided with a stainless steel drain pan.

B. The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer’s requirements. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the sections primary drain pan.
C. The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to

D. All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted. **Connections must be above the equipment base rail.**

E. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2-inch beyond the base to ensure adequate room for field piping of condensate traps.

F. The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer’s requirements, and visually inspected to ensure proper drainage of condensate.

G. Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.

2.5 INSULATION

A. Double-wall units shall be factory insulated with R-13 injected foam insulation.

2.6 FANS

A. Acceptable fan array assembly shall consist of a total quantity of 4 single width, single inlet, class II, direct-drive type plenum fans dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. All fan assemblies shall be dynamically balanced by the manufacturer on all three planes.

1. Walk in access section placed downstream for motor access.
2. Unit shall come equipped with an isolation damper upstream of each fan in the array. Damper shall be equipped with an adjustable, weighted counter balance to minimize static pressure loss.
3. Fan array section shall come with sound absorbing panels installed around each fan.

B. Fan array shall have fans individually isolated with spring isolators.

C. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

2.7 BEARINGS, SHAFTS, AND DRIVES

A. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be designed for service with an L-50 life of 200,000 hours and shall be a heavy duty pillow block, self-aligning, grease-lubricated ball or spherical roller bearing type.
B. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

C. V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Fixed sheaves, matched belts, and drive rated based on motor horsepower. Minimum of 2 belts shall be provided on all fans with 10 HP motors and above. Standard drive service factor minimum shall be 1.1 S.F. for 1/4 HP – 7.5 HP, 1.3 S.F. for 10 HP and larger, calculated based on fan brake horsepower.

2.8 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPAct requirements), 1750 RPM, single speed, 460V / 60Hz / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.

B. The air handler(s) shall be ETL listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.

C. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.

D. Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

E. Provide marine light, in each section as shown on project schedule, mounted and wired to a junction box with an on-off switch and GFI receptacle mounted on the outside of the cabinet.

2.9 COILS

A. Casing: Provide access to both upstream and downstream of coils. Enclose coils with headers and fully contain within casing unless otherwise noted on mechanical equipment schedule.

B. Drain Pans: Provide additional drain pans for cooling coil banks more than one coil high.

C. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

D. Fabrication:

1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
2. Fins: Aluminum.

E. Water Heating Coils:

1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

F. Water Cooling Coils:

1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
2. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.

2.10 HUMIDIFIER

A. Humidifiers: Certify capacities and selection in accordance with ARI 610.

B. Provide blank-off panels as recommended by humidifier manufacturer. See humidifier schedule for additional information.

2.11 FILTERS

A. Filter Box: Section with filter guides, access from both upstream and downstream, for side or face loading.

B. Filter Media: As scheduled.

3. EXECUTION

3.1 INSTALLATION

A. Examine rough-in for hydronic, condensate drainage piping and electrical to verify actual locations of connections prior to installation.

B. Do not proceed until all unsatisfactory conditions have been corrected.

C. Install central-station air-handling units level and plumb, in accordance with manufacturer's written instructions, on base rail at height specified.

D. Support floor-mounted units on concrete equipment bases. Secure units to anchor bolts installed in concrete equipment base.

E. Arrange installation of units to provide maximum access space around air-handling units for service and maintenance.

F. If unit is operated prior to substantial completion, contractor is fully responsible for all preventative maintenance. Preventative maintenance to be completed per all manufacturer recommendations.
G. The air handling units, exhaust fans, and other HVAC airside equipment shall not be used for temporary building conditioning without the written permission from the Owner and Architect/Engineer.

3.2 EQUIPMENT BASES

A. See Section 23 05 00.

3.3 COMMISSIONING

A. Perform the following operations and checks before start-up:

1. Adjust damper linkages for proper damper operation.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face.
3. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
5. Install clean filters. Install clean filters again at time of substantial completion.
   a. Replace fan and motor sheaves as required to achieve design conditions or as directed by the Engineer. Contractor shall be responsible for any and all change outs required.

6. Measure and record motor electrical values for voltage and amperage.

B. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

END OF SECTION 23 73 13
SECTION 23 82 16 - AIR COILS

1. GENERAL

1.1 SECTION INCLUDES

A. Water coils.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.
B. References.
C. Submittals.
D. Operation and maintenance manuals.
E. Project record documents.

1.3 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.
B. Protect coils from entry of dirt and debris with pipe caps or plugs.

2. PRODUCTS

2.1 WATER COILS

A. Headers: Cast iron with tubes expanded into header, 5/8” OD seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
B. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.
C. See drawings for further information.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

C. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide airtight seal between coil and duct or casing.

D. Protect coils to prevent damage to fins and flanges. Comb out bent fins.

E. Install coils level.

F. Make connections to coils with unions and flanges.

G. On water coils, provide shut-off valve on supply line and lockshield balancing valve on return line. Locate water supply at bottom of supply header and return water connection at top. Provide manual air vents at high points complete with stopvalve. Ensure water coils are drainable and provide drain connection at low points.

H. Connect water supply to leaving air side of coil (counterflow arrangement).

I. Insulate headers located outside air flow as specified for piping.

J. Install blank-off panels as required to ensure all air passes through coils.

END OF SECTION 23 82 16
SECTION 23 82 39 - TERMINAL HEAT TRANSFER UNITS

1. GENERAL

1.1 SECTION INCLUDES

A. Unit heaters.

B. Cabinet unit heaters and fan coil units.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

1.3 SEQUENCING AND SCHEDULING

A. See Section 23 05 00.

B. Install cabinet unit heaters only after walls and ceiling are finished and painted.

2. PRODUCTS

2.1 UNIT HEATERS

A. General: Provide unit heaters in locations indicated on the plans. Provide units of capacities, styles, features and accessories as scheduled. Unless otherwise noted on plans, provide same end coil connections.

B. Coils: Seamless copper tubing with evenly spaced aluminum fins mechanically bonded to tubing. Design coils for steam or hot water usage.

C. Casing: 18 gage steel with connections for hanger rods.
TERMINAL HEAT TRANSFER UNITS

D. Finish: Factory apply baked enamel on visible surfaces of enclosure or cabinet.

E. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

F. Air Outlet: Adjustable pattern diffuser on vertical models and four way louvers on horizontal throw models.

G. Motor: Refer to Section 23 05 13, horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

H. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
   1. Trane Inc.
   3. Engineered Air.
   4. Or equivalent.

2.2 CABINET UNIT HEATERS AND FAN COIL UNITS

A. General: Provide cabinet unit heaters in locations indicated on the plans. Provide units of capacities, styles, features and accessories as scheduled.

B. Coils: Evenly spaced aluminum fins mechanically bonded to copper tubes, designed for chilled water or hot water use.

C. Cabinet: 16 gage steel with exposed corners and edges rounded, easily removed panels, glass fiber insulation.

D. Finish: Factory applied baked enamel on visible surfaces of enclosure or cabinet. Color to be selected by Architect from manufacturer’s standard color chart.

E. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.

F. Motor: Refer to Section 23 05 13; sleeve bearings, resiliently mounted.

G. Filter: Easily removed one inch thick glass fiber throw-away type, located to filter air before coil.

H. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
   1. Trane Inc.
   2. Daikin Applied.
3. **EXECUTION**

3.1 **EXAMINATION**

A. Verify that required utilities are available, in proper location, and ready for use.

B. Beginning of installation means installer accepts existing surfaces.

3.2 **INSTALLATION**

A. Install in accordance with manufacturer's instructions.

B. Hang unit heaters from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

C. Install cabinet unit heaters and fan coil units as indicated. Coordinate to assure correct recess size for recessed units.

D. Locate panel radiators as indicated on plans. Install elements as indicated on plans. Install accessories as noted on the plans. Provide backing inside the wall cavity or floor stands as recommended by the manufacturer. Coordinate exact mounting height and locations with architectural drawings.

E. Protect units with protective covers during balance of construction.

F. Provide hydronic units with valving as detailed on the plans.

3.3 **CLEANING**

A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Comb all bent fins on coils.

END OF SECTION 23 82 39
SECTION 26 05 00 - ELECTRICAL GENERAL PROVISIONS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1-specification sections, apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. The work included under this Section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete electrical systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, conduit, and outlets. Follow the drawings in laying out the work and verify spaces for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Engineer before proceeding with the work.

C. Portions of this facility (as indicated on the drawings) are classified as a Bio Safety Level 3 (BSL3) facility. All penetrations into the BSL3 area must be adequately sealed as outlined within the drawings and these specifications.

1.3 QUALITY ASSURANCE

Installers shall have at least 2 years of successful installation experience on projects with electrical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation.

1.4 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following codes, standards and regulations, etc.:

1. Safety and Health Regulations for Construction.
2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
5. National Electric Manufacturer's Association (NEMA).
ELECTRICAL GENERAL PROVISIONS

6. Institute of Electrical and Electronic Engineers (IEEE).
8. Insulated Cable Engineers Association (ICEA).
12. Factory Mutual Engineering Corporation or other recognized National Laboratories.

B. The latest adopted edition by the local and state inspection authorities of all standards and specifications listed above shall apply.

C. Furthermore, the electrical work shall be in accordance with all applicable National and State Standards, and Local Codes and Building Ordinances. The electrical work shall merit the approval of the enforcing authorities having jurisdiction.

1.5 MATERIALS AND EQUIPMENT

A. Electrical materials and equipment for the entire project shall meet the requirements specified under the Supplementary Conditions Section of this specification.

B. Equipment and fixtures shall be connected to provide circuit continuity in accordance with applicable Codes whether or not each piece of conductor, conduit, or protective device is shown between such items of equipment or fixtures and the point of circuit origin.

C. The electrical work includes the installation or connection of certain materials and equipment furnished by others. Verify all connection details.

D. All equipment over 50 pounds shall be provided with adequate lifting means.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 ACCESS TO EQUIPMENT

A. Starters, switches, receptacles, pull boxes, etc. shall be located to provide easy access for operation, repair and maintenance. If the devices listed above are concealed, access doors shall be provided.

3.2 SUBMITTALS

A. Test Reports: Provide the tests as outlined in this specification and all other tests necessary to establish the adequacy, quality, safety, completed status, and suitable operation of each electrical system. Provide the Engineer with a complete schedule of all tests.
1. **Ground Rod Test:** Immediately after installation, test driven grounds and counterpoises with a ground resistance direct-reading single-test megger, using the AC fall-of-potential method and two reference electrodes. Orient the ground to be tested and the two reference electrodes in a straight line spaced 50 feet apart. Drive the reference electrodes five feet deep. Disconnect the ground rod to be tested from other ground systems at the time of testing. The ground resistance for the electrical service must be 15 Ohms or less. Submit the results, date of test, and soil conditions to the Engineer in writing immediately after testing.

2. **Final Tests:** Start final tests after complete preliminary tests have been made which indicate adequacy, quality, completion, and satisfactory operation of all electrical systems. Included in these tests are the following:
   a. Completion of the form "Electrical Test Report" (attached to the end of this specification section) in sufficient quantity to provide the indicated information for each panelboard and switchboard in the project.
   b. Completion of the form "Motor Test Report" (attached to the end of this specification section) in sufficient quantity to provide the indicated information for all three phase motors.

3. The Contractor shall submit the above completed reports to the Engineer, noting all deviations from the requirements listed below:
   a. Plus or minus five percent variation between nominal system voltage and no load voltage, or plus or minus five percent variation between no load and full load voltage.
   b. Plus five-percent variation between rated and actual motor current.
   c. Plus or minus ten percent variation between average phase current and measured individual phase current. The Contractor shall balance phase currents of all distribution equipment within the tolerances specified.
   d. Insulation resistance between conductors and ground of not less than 1,000,000 Ohms.

4. **Final Corrections:** Correct promptly any failure or defects revealed by these tests as determined by the Engineer. Reconduct tests on corrected items as directed by the Engineer.

**B. Operation and Maintenance Manuals:** Operation and Maintenance Manuals shall be provided according to Division 1 requirements. In general, during the time of the contract, and before substantial completion of the electrical installation, submit to the Engineer the number of copies described in the Division 1 specifications and the General and Supplemental Conditions copies of descriptive literature, maintenance recommendations (from the equipment manufacturer), data on initial operation, wiring diagrams, performance curves, engineering data and tests, operating procedures, routine maintenance procedures, and parts lists for each item of electrical equipment installed under this contract and submit all manufacturer's guarantees and warranties.
C. Shop Drawings: The Contractor shall furnish shop drawing portfolios and proper transmittal forms for all materials, equipment, and lighting fixtures to be incorporated in the work in accordance with the General Conditions, Supplementary Conditions, and all other applicable Conditions.

1. Shop drawings on component items forming a system or that are interrelated shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function properly as a system. A notation shall be made on each shop drawing submitted as to the item’s specific use, either by a particular type number referenced on the drawings or in the specifications, by a reference to the applicable paragraph of the specifications, or by a description of its specific location. The shop drawings shall be organized and bound into sets with each set collated.

2. The Engineer shall have the final authority as to whether the equipment or material submitted is equal to the specified item. Proposed substitutions may be rejected for aesthetic reasons if felt necessary or desirable. In the event the proposed substitutions are rejected, the Contractor shall furnish the specified item.

D. Coordination/Short Circuit Study: Reference Specification Section 26 05 73 – Low Voltage Electrical Systems Studies

E. Arc Flash Hazard Analysis: Reference Specification Section 26 05 73 – Low Voltage Electrical Systems Studies

3.3 EXISTING UTILITIES

A. The Contractor shall verify the location of all existing utilities with the Owner and Utility providers prior to commencing excavation work. In addition, the contractor is responsible for locating and maintaining all existing utilities without damage. Fully coordinate all new underground utility work with existing utilities on the site. The drawings and survey data of the contract documents indicate the available information on the existing power and communication services, and on new services to be provided to the project by utility provider. Accuracy of this information is not assured.

3.4 ELECTRICAL PRODUCT COORDINATION

A. Refer to Division 2 through Division 32 and the electrical drawings for the power characteristics required and available for the operation of each power-consuming item of equipment. Coordinate purchases to ensure uniform interface with every item requiring electrical power.

3.5 CUTTING AND PATCHING

A. The Electrical Contractor shall be responsible for all cutting and patching of holes in building construction which are required for the passage of electrical work. Cutting and patching shall conform to the requirements of Division 1 and, if applicable, Division 2 of these specifications.
B. Cutting of structural framing, walls, floors, decks and other members intended to withstand stress is not permitted.

3.6 PAINTING, FINISHING

A. Painting of electrical work exposed in occupied spaces, except mechanical and electrical machine rooms and maintenance/service spaces; and work exposed on the exterior of the facility is specified and performed under other divisions of these specifications.

B. Factory finishes, shop priming, and special protective coatings are specified in the individual equipment specification sections.

C. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.

3.7 EXCAVATION AND BACKFILLING

A. Contractor shall perform all excavation and backfilling necessary to install the required electrical work. Coordinate the work with other excavating and backfilling work in the same area. Except as indicated otherwise, comply with the applicable sections in Division 31 of these specifications, excavation filling and backfilling (for structures) to 5’ outside the building line, and exterior utilities sections for beyond 5’ from the building line.

B. Landscape work, pavement, flooring and similar exposed finish work that is disturbed or damaged by excavation shall be repaired and restored to their original condition by the Contractor.

3.8 CONDUITS AND SUPPORT, GENERALLY

A. Conduits, except electrical conduits run in floor construction, shall be run parallel with or perpendicular to lines of the building unless otherwise noted on the drawings. Electrical conduits shall not be hung on hangers with any other service, unless specifically approved by the Engineer. Electrical conduits shall be hung above all other service pipes. Hangers on different service lines running close to and parallel with each other shall be in line with each other and parallel with, or perpendicular to, the lines of the building. Exact location of electric outlets, piping, ducts, and the like shall be coordinated to avoid interferences between lighting fixtures, piping, ducts, and similar items.

3.9 ACCESS PANELS

A. Furnish and install panels for access to junction boxes and similar items where no other means of access, such as a readily removable, sectional ceiling is shown or specified.
B. Panels shall not be less than 12-inches by 16-inches in size. Larger panels shall be furnished where required. Panels in tile or other similar patterned ceilings shall have dimensions corresponding to the tile or pattern module.

1. Refer to Section 08 31 13 – Access Doors and Panels for specific information on type and size of panels

3.10 INSTALLATION OF EQUIPMENT

A. Install and connect all appliances and equipment as specified and indicated for this project, in accordance with the manufacturers' instructions and recommendations. Furnish and install complete electric connections and devices as recommended by the manufacturer or required for proper operation.

3.11 ELECTRICAL DEMOLITION

A. Refer to Division 01 Sections for general demolition requirements and procedures.

B. Refer to the drawings for additional demolition requirements.

C. Disconnect, demolish, and remove electrical systems, equipment and components specified under Divisions 26, 27 & 28 and as indicated on the drawings.

1. For conductors serving devices shown to be removed: Disconnect the device and remove all conduit and conductors back to the panel or to the next device shown to remain or as required by actual circuiting.

2. Coordinate all phasing and related electrical system outages with the Owner and all other disciplines.

3. For mechanical equipment indicated shown to be removed on either the mechanical and/or the electrical plans: Disconnect the equipment and remove all conduit, conductors and associated electrical supply equipment. Remove conduit and conductors back to the panel or the next device shown to remain or as required by actual circuiting.

3.12 COORDINATION DRAWINGS

A. Coordinate the electrical work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.

2. Within the limits indicated on the drawings, the maximum practicable space for operation, repair, removal and testing of electrical and other equipment will be provided.

3. Pipe, conduits, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, conduits, ducts, and
similar items shall be located so that they will not interfere with the intended use of other equipment.

B. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

C. Before any sleeves or inserts are set, or any electrical equipment or foundations are installed, prepare and submit for approval composite coordination drawings for all equipment rooms, and other areas in which work of two or more trades or subcontractors is to be installed and in which the probability of interference exists. Drawings shall show the work of all trades covered, shall be drawn to a scale not smaller than $1/2" = 1'-0"$, and shall show clearly in both plan and elevation that all work can be installed without interference.

D. Any work installed prior to approval of coordination drawings shall be at the Contractor's risk. Subsequent relocations required to avoid interference's shall be made without additional expense to the Owner.

3.13 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number (such as "the switch"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

3.14 WARRANTY

A. Refer to the General Conditions section of this Specification for warranty requirements and information.

3.15 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Sequence operations properly so that all work of this project will not be damaged or endangered. Operate each item of equipment and each system in a test run of appropriate duration to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Conduct a full-day walk-through instruction seminar for the Owner's personnel to be involved in the continued operation and maintenance of electrical equipment and systems. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, security, safety, efficiency and similar features of the systems.

C. At the time of substantial project completion, turn over the prime responsibility for operation of the electrical equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

SUBSTITUTIONS
D. All proposals shall be based on providing and installing the materials or items of equipment which are hereinafter specified by name and/or manufacturer. Substitutions, for materials or items of equipment specified, will not be allowed, unless approved by Engineer prior to (10 days before) bid date.

E. Refer to Instructions to Bidders for complete requirements for substitutions.

3.16 AS-BUILT DRAWINGS

A. Contractor shall provide the Owner with as-built drawings for all electrical systems as described in these specifications and/or shown on the Drawings.

END OF SECTION 26 05 00
## MOTOR TEST REPORT

**DATE:** ______________________
**SHEET NO. _______ OF ________**

**PROJECT NAME:** ____________________________________________________________

**PROJECT NUMBER:** __________________________________________________________

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ELECTRICAL GENERAL PROVISIONS

26 06 00-9
## ELECTRICAL TEST REPORT

**DATE:**

**SHEET NO. _____ OF ______**

### PROJECT NAME:

### PROJECT NUMBER:

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**ELECTRICAL GENERAL PROVISIONS**

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**The Clark Enersen Partners**
### ELECTRICAL GENERAL PROVISIONS

#### University of Missouri Health Care
**AP Green Building Laboratory Consolidation**
Columbia, Missouri

#### Contract Documents
- **MU Project #:** CP190421
- **TCEP Project #:** 624-157-18

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<th>VOLTAGE</th>
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<td>OPERATING LOAD FEEDER VOLTAGE</td>
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SECTION 26 05 01- BASIC MATERIALS AND METHODS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. The extent of Basic Materials and Methods is indicated by the drawings and specifications. Basic materials are defined but not limited to cable and conduit seals, outlet boxes, pull boxes, conduit fittings, safety switches, and fuses.

1.3 QUALITY ASSURANCE

A. Manufacturers: All materials shall be new, unused, and unweathered, and of the quality specified. Materials shall be standard products of manufacturer's regularly engaged in the production of such equipment and shall be the manufacturer's latest standard design.

B. Installer: All equipment and materials shall be installed in a neat and workmanlike manner, shall be complete in both effectiveness and appearance, whether finally concealed or exposed and shall be executed by experienced mechanics.

1.4 REFERENCES

A. The electrical work shall conform to all applicable sections of standards, codes and specifications promulgated by organizations listed below.

1. Occupational Safety and Health Standard, National Consensus Standards and Established Federal Standards
2. National Electrical Code (NEC)
3. National Electric Manufacturer's Association (NEMA)
4. American Society for Testing of Materials (ASTM)
5. Underwriters Laboratories, Inc. Standards (UL)
6. Factory Mutual Engineering Corporation or other Recognized National Laboratories

1.5 SUBMITTALS
2. PRODUCTS

2.1 Equipment and Materials Furnished by Others: Certain materials and equipment for this project will be furnished under other divisions. These materials and equipment, which are shown or noted on the plans, will be installed and/or connected under this Division. It shall be incumbent upon this Contractor to become familiar with all of the materials and equipment that will be furnished under other Divisions, but which will be installed and/or connected under this Division.

2.2 Cable and Conduit Seals: Seals shall be provided around all conduits and cables which penetrate smoke walls, fire walls, and floors. Nelson Flameseal System shall be used to seal penetrations of electrical cables and conduits.

A. Materials used shall be flameseal putty, ceramic fiber insulation and where rigid support on large oversized openings is required, ceramic fiber board. Board shall be rigid and able to withstand temperatures in excess of 2000 degrees F.

B. Accessory hardware shall be provided as required on oversized openings.

C. Follow manufacturers instructions in selecting the type of seals and accessories. Also follow the manufacturers instructions on installation of the cable and conduit seals. Equal quality equipment by OZ Gedney and 3M shall be acceptable.

2.3 BSL3 Area Sealants: All penetrations into the BSL3 area and containment area environments, including all conduits, cables, boxes, electrical devices, etc. shall be adequately sealed to maintain the environment. ASTM C920 compliant sealing and caulking compound shall be used to seal around all raceway, cable and box penetrations through Animal Area walls, ceilings and floors. Provide 100% silicone sealant between all surface mounted electrical devices and finished walls and ceilings within the BSL3 Area. Provide 100% silicone sealant between flush mounted electrical device faceplates and finished walls and ceilings within the BSL3 Area. Provide non-halogenated latex-based elastomeric sealant along the perimeter of the lighting fixture housings where the housing of the fixture penetrates the animal area ceiling. No additional caulking is required around the perimeter of the flange of the fixture. Reference electrical details for additional sealant and caulking information.

2.4 Outlet Boxes, Pull Boxes and Conduit Fittings: Furnish and install outlet boxes, pull boxes, and conduit fittings as described below. Catalog numbers shown are Appleton Electric Company; Steel City, O.Z. Gedney, and Raco, are equally acceptable.

A. OUTLET BOXES
1. Lighting Boxes (concealed) No. 40-3/4
2. Lighting Boxes (concrete) OCR Series
3. Lighting Boxes (exposed) 4S-3/4 or 40-3/4
4. Flush Switches, Receptacles No. 4S-3/4 with separate
   Telecommunications and Flush in masonry construction (* refers
   Junction Boxes to number of devices in the box)
5. Weatherproof type Switch, FS or FD Series w/ FS or FD cover and
   Receptacle and Telecommunications neoprene gasket.
   Boxes (exposed) and
   all devices installed within the BSL3 Area
6. Switch, Receptacle and 4S-3/4 with 8360 or 8370
   Telecommunications Boxes (exposed) series raised surface cover.
7. Telecommunications Boxes
   a. At minimum, the typical communications backbox shall be 4-11/16-inch square by
      2-1/8- inch deep with 1-1/4-inch knockouts and a 4-11/16-inch Square Mud-Ring
      for one (1) device (single-gang) unless noted otherwise.
   b. For outlets in stud wall, Manufacturer shall be:
      1) RACO/Hubbel Electrical Products – 4-11/16-inch Square Box, 2-1/8-inch
         Deep, 1-1/4-inch Side Knockouts. (P/N RACO259) with 4-11/16-inch Square
         Mud-Ring for one (1) device (verify appropriate Mud-Ring depth).
      2) Randl Industries, Inc. – 5-square Telecommunications Outlet Box (P/N
         T55017) with appropriate mud-ring.
      3) Or approved equivalent.
   c. For outlets in CMU wall, submit appropriate backbox for application.
   d. For outlets above ceiling for applications such as Wireless Access Points
      1) Grainger Single-gang Galvanized Steel Box (P/N 2DDB6) with Grainger 3/4"
         nipple (P/N 1UGX5), two (2) Grainger 3/4" lock nuts (P/N 5XC31) and a
         Grainger 3/4" plastic bushing (P/N 5XC35).
      2) Or approved equivalent.
B. Extension and plaster rings shall be installed as required by the NEC.

C. Outlet boxes shall comply with the National Electrical Code in regard to the allowable fill.

2.5 PULL BOXES

A. Pull boxes shall be fabricated of code gauge galvanized sheet metal and shall be sized in accordance with the National Electrical Code requirements or as shown on the drawings. Provide removable cover on the largest access side of the box. In-line conduit pull boxes may be O.Z., Type PBW, or equal. Provide pull boxes at all code required locations, and as needed to aid in cable pulling.

2.6 SAFETY SWITCHES

A. Furnish and install heavy duty type safety switches, having the electrical characteristics, ratings and modifications shown on the drawings. All switches shall have:

B. NEMA 1 general purpose enclosures unless otherwise noted for all interior applications;

C. NEMA 3R rainproof enclosures unless otherwise noted for all exterior applications and inside all mechanical rooms;

D. NEMA 4/4X stainless steel enclosures unless otherwise noted in all rooms containing autoclave sterilizers.

E. Fully rated neutral assemblies;

F. Equipment grounding kits;

G. Metal nameplates, front cover mounted that contain a permanent record of switch type, catalog number and H.P. ratings with both standard and time delay fuses;

H. Handle that is padlockable in "OFF" position;

I. Non-telescable, positive quick-make, quick-break mechanism;

J. UL approval and shall bear the UL label;

K. All fusible switches shall have Class R Fuse rejection clips.
L. Safety switches, as manufactured by the following, will be equally acceptable, but all safety switches furnished by this Contractor shall be the product of one manufacturer:

1. Square D Company
2. General Electric
3. Cutler Hammer
4. Siemens

2.7 FUSES

A. Fuses shall be furnished and installed in each fused switch, and shall be rated as shown on the drawings.

B. Provide fuses according to the following and in accordance with recommendations of manufacturers whose equipment is being protected:

1. Provide UL Class L current limiting time-delay fuses rated 600-volts, 60 Hz, 601 to 6000 amps, with 200,000A RMS symmetrical interrupting current rating for protecting transformers, motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
2. Provide UL Class L current limiting fast-acting fuses rated 600-volts, 60 Hz, 601 to 6000 amps, with 200,000A RMS symmetrical interrupting current rating for protecting service entrances and main feeder circuit breakers. (Similar to Buss Limitron fuses.)
3. Provide UL Class RK1 current limiting, dual-element, time-delay fuses rated 600-volts, 60 Hz, 1/10 to 600 amps, with 200,000A RMS symmetrical interrupting current rating for protecting motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
4. Provide UL Class RK1 current-limiting fuses rated 250-volts, 60 Hz, 1/10 to 600 amps, with 200,000A RMS symmetrical interrupting current for protecting motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
5. Provide UL Class J current-limiting fuses rated 600-volts, 60 Hz, 1 to 600 amps, with 200,000A RMS symmetrical interrupting current rating for protecting circuits with no heavy inrush current where reduced dimension devices are required.
6. Provide UL Class H fuses rated 600-volts, 60 Hz, 1/10 to 600 amps, with 10,000A RMS symmetrical interrupting current rating for protecting general purpose light duty feeders.
7. Provide UL Class T fuses rated 600-volts, 60 Hz, 1 to 1,200 amps, with 200,000A RMS symmetrical interrupting current rating for protection of non-motor loads where reduced dimension devices are required.

C. Three spare fuses shall be furnished for each size and type used. Each fused switch shall be provided with a mastic backed label clearly identifying the type and size of fuse required.

3. EXECUTION

3.1 PRODUCT INSTALLATION, GENERAL
A. Except where more stringent requirements are indicated, comply with product manufacturer's installation instructions and recommendations, including handling, anchorage, assembly, connections, cleaning and testing.

3.2 MOUNTING HEIGHTS

A. Mounting heights to the center of the box above finished floor for the items listed below shall be as follows, unless otherwise shown. All other device mounting heights shall be as shown on the drawings. All devices shall be mounted in accordance with ADA (Americans with Disabilities Act) requirements.

B. Flush tumbler switches and lighting controls 46"

C. Switches in concrete block 46"

D. Switches over wainscot 6" above 48" wainscot

E. Convenience outlets 18" mounted vertically with ground prong slot at bottom

F. Safety switches 54"

G. Motor controllers 54"

H. Panelboards to top 72"

I. Telecommunications outlets 18"

J. Telecommunications outlets (pay and wall type) 54" for non-ADA type

K. Clock outlets 8' ceiling 84"

L. Receptacles above counters 8" above counters mounted vertically

M. Convenience outlets in mechanical, electrical, telecommunications, janitor and elevator machine rooms 48"
N. Exterior W.P. convenience 24" above grade mounted outlets

O. Fire alarm pull station 46"

P. Fire alarm horn, speaker, bell chime 84"
   And/or strobe

Q. Intercom System Pushbutton 46"
   Stations

R. Card Readers 46"

S. Contractor shall check all equipment layouts and verify exact mounting heights.

3.3 CUTTING AND PATCHING FLOORS, WALLS OR CEILINGS

A. Cutting, patching, repairing, and finishing of carpentry work, metal work, or concrete work, etc., which may be required for this work shall be done by craftsmen skilled in their respective trades. When cutting is required, it shall be done in such a manner as not to weaken walls, partitions, or floors. Holes required to be cut in floors must be drilled without breaking out around the holes. Cutting, patching, and painting shall conform to the requirements of the General Conditions section of this Specification.

B. Cutting of structural framing, walls, floors, decks, or other members intended to withstand stress is not permitted.

C. Sleeves through floors or walls shall be black iron pipe and shall be flush with finished faces of floors, walls or ceilings. Sleeves shall be sized to accommodate raceways indicated.

D. Use care in piercing water proofing. After the part piercing the waterproofing has been set in place, seal openings, and make absolutely watertight.

3.4 SLEEVES

A. Sleeves shall be used to accommodate conduit or tubing where conduit or tubing pass through newly poured concrete walls or slabs.

B. All sleeves through floors and walls shall be black iron pipe, flush with walls or finished floors; and of sizes to accommodate the raceways shown. Sleeves through outside walls above grade shall be caulked with approved caulking compound. Sleeves shall not be required through on grade slabs.
C. For raceways which enter buildings below grade, install manufactured floor and thruwall seals, similar to Type "FSK" or "WSK" as manufactured by O.Z. Electric Manufacturing Co.

3.5 INSTALLATION METHODS

A. Conductors shall be installed in concealed raceways except as shown otherwise on the drawings or specified to be otherwise in these specifications. Exposed conduits and wires shall be installed parallel or perpendicular to building surfaces. Conduits and wires in the space above ceilings shall be supported adequately and shall not be laid on the top of ceiling systems. Conduits and wires installed above ceilings shall be considered exposed.

B. Electrical conduits shall not be hung on hangers with any other service foreign to the electrical systems, nor shall they be attached to other foreign services.

C. The lighting and power branch circuit conductors shall be installed in separate raceway systems unless specifically shown or noted otherwise.

D. Equipment Bases. Provide concrete equipment bases for all floor mounted equipment furnished under this contract. Concrete bases shall be 3-1/2"-inches high unless noted otherwise and shall extend 3-inches beyond all sides of the unit. Trowel all edges at a 45 degree angle. This work shall be done in accordance with Division 3 of the specifications by the Division 26 Contractor. Bases shall be provided for switchboards, motor control centers, transformers and all other floor mounted equipment.

E. Outlet Box Locations. Outlet boxes shall be located so they are not placed back-to-back in the same wall, and in metal stud walls, are separated by at least one stud space in order to limit sound transmission from room to room. Outlet boxes installed on opposite sides of fire rated walls shall be spaced at least 24" apart.

3.6 WIRING - NUMBER OF WIRES REQUIRED

A. The number of wires for lighting and receptacle branch circuits is shown on the drawings. The number of wires in any circuit is determined in accordance with the National Electrical Code, and wiring is provided to perform all functions of the devices being installed. Additionally, wires shall be provided as required by the contract documents, i.e. equipment grounds, etc. Provide the number of wires required for a complete and workable system.

3.7 PROTECTION FROM WEATHER

A. Raceway stub ups shall be capped or otherwise protected from moisture and debris until such time that the conductors are pulled. Conduits shall not be installed in raceways until the building is protected from the weather, all concrete and plastering is completed, and raceways in which moisture has collected have been swabbed or blown out.
3.8 ELECTRICAL ROOM COORDINATION

A. Where a number of electrical panels and/or related electrical items are shown, the Electrical Contractor shall coordinate the physical sizes with his equipment suppliers to ensure that there is adequate space for the items shown to be installed in those areas and that all Code required clearances are maintained.

B. The Contractor shall rearrange the equipment layout to achieve full use of the available space prior to installing conduit stub ups. Where a conflict or rearrangement exists, the Contractor shall submit a proposed revised layout of the area to the Engineer.

3.9 NAMEPLATES

A. Nameplates shall be provided for all items such as panelboards, cabinets, motor controllers (starters), safety switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards and motor control centers, control devices and other significant equipment.

B. Nameplates shall be 1”x 2-1/2” laminated black phenolic resin with a white core with engraved lettering, a minimum of 3/16-inch high. Manufacturers factory installed nameplates shall be acceptable provided all information is furnished.

C. Nameplates shall identify the equipment item that the device is serving and also from where the device is being fed from. Nameplates shall also identify the system voltage of the item of equipment.

3.10 RACEWAY SUPPORTS

A. Raceways shall be securely supported and fastened in place with pipe straps, wall brackets, caddy clips, hangers or trapeze hangers at intervals specified in Section 26 05 33 "RACEWAYS" or:

1. As shown on the drawings.

2. As may be required by special adverse field conditions.

B. Spring tension clamps on building steel work may be used only by special permission.

C. Fastenings shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws or welded threaded studs on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine
wood screws. Threaded C-clamps shall not be used. Raceways or pipe straps shall not be welded to steel structures. Holes cut in reinforced concrete beams or in concrete joists shall avoid cutting the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws may be used, and bar hangers may be attached with saddle ties of not less than No. 16 AWG double strand zinc-coated steel wire. No raceway shall be attached to the suspended ceiling construction. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts and insulating bushings.

3.11 BOX SUPPORTS

A. Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Plastic expansion shields shall not be used. Threaded studs driven in by powder charge and provided with lockwashers and nuts may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Raceways shall be supported with an approved type fastener not more than 24-inches from the box. Penetration into reinforced concrete beams and into reinforced-concrete joists shall avoid cutting any main reinforcing steel.

3.12 LIGHTING FIXTURE SUPPORTS

A. Lighting fixtures shall be supported as follows and in accordance with all applicable Codes and Regulations:

1. By fixture studs or other devices securely attached to outlet box, or;
2. By special hangers designed and intended for use as lighting fixture supports, or;
3. By a special clip or device attached to the ceiling system grid designed to secure the lighting fixture in place or;
4. By other methods and devices designed and intended for use as lighting fixture support, or;
5. As shown on the drawings.
6. All lighting fixtures installed in grid type suspended ceiling systems, shall be positively attached to the ceiling system with clips that are UL listed for the application. In addition, a minimum of four (4) ceiling support system rods or wires shall be provided for each light fixture and shall be installed not more than six (6) inches from fixture corners. Provide two (2) No. 9 gage hangers from each fixture housing to the building structure above (wires may be installed slack). Light fixtures that weigh more than 56 pounds shall be supported directly from the structure above by UL listed and approved hangers. Light fixtures that are smaller than the ceiling grid shall be installed at locations indicated on the reflected ceiling plans, or shall be installed in the center of the ceiling panel and shall be
supported independently by at least two metal channels that span and are secured to the ceiling system.

7. Suspended lighting fixtures shall be supported directly from the building structure without using suspended ceilings as support systems. Support systems shall be UL listed and approved for the specific installation. Where pendants or rods exceed 48 inches in length, brace support systems to limit swinging.

B. The lighting fixture support system detail shall be submitted with and be a part of the lighting fixture shop drawing submittal.

C. Lighting fixtures shall not be supported from the leg of pre-cast pre-stressed concrete.

END OF SECTION 26 05 01
SECTION 26 05 19 - CONDUCTORS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work in this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to conductors.

1.2 Description of Work: Extent of electrical wire and electrical cable work is indicated by drawings and schedules. Types of wire, cable and connectors in this Section include the following:

A. Conductors

B. Power-limited circuit cable

C. Service entrance cable

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of electric wire and cable products of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer: Qualified with at least 3 years of successful installation experience on projects with electrical wiring work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wire, cable and connectors.

B. UL Compliance: Comply with UL standards pertaining to wire cable and connectors.

C. UL Labels: Provide electrical wires, cables and connectors which have been UL-listed and labeled.
D. NEMA/ICEA Compliance: Comply with applicable portions of NEMA/Insulated Cable Engineers Association Standards pertaining to materials, construction and testing of wire and cable.

E. ANSI/ASTM: Comply with applicable portions of ANSI/ASTM standards pertaining to construction of wire and cable.

F. IEEE Compliance: Comply with applicable portions of IEEE standards pertaining to wire and cable.

G. NECA Compliance: Comply with NECA's "Standard of Installation."

1.5 SUBMITTALS

A. Submit manufacturer's data on electric wire and cable.

2. PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of wire, cable and connector):

A. WIRE AND CABLE:

1. Advance Wire and Cable, Inc.
2. Cerro Wire and Cable, Co.
3. Electrical Conductors, Inc.
4. General Cable Corp.
5. Hitemp Wires, Inc.
6. Rome Cable Corp.
7. Southwire Company
8. The Okonite Company

B. CONNECTORS:

1. Amp, Inc.
2. Burndy Corp.
5. Ideal Industries, Inc.
7. O-Z/Gedney Co.
8. Pyle National Co.
9. Thomas and Betts Co.
2.2 WIRE, CABLE, AND CONNECTORS

A. General: Except as otherwise indicated, provide wire, cable and connectors of manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by manufacturer, and as required for the installation.

B. WIRE:

1. All conductors shall be 600-volt and shall be copper, soft drawn, annealed, having a conductivity of not less than 98% pure copper with dual rated type THHN/THWN insulation unless otherwise specified or indicated on the drawings.

2. No wire shall be smaller than No. 12 AWG, except wiring for signal and pilot control circuits, and pre-manufactured fixture whips for light fixtures.

3. All wire No. 12 AWG shall be solid unless otherwise indicated within these specifications.

4. All wiring installed in light poles or other areas subject to vibration shall be stranded.

5. Wire sizes shown are minimum based on code requirements, voltage drop and/or other considerations. Larger sizes may be installed at the Contractor’s option to utilize stock size, provided conduit sizes are increased where necessary to conform to the National Electrical Code. Sizes of wires and cables indicated or specified are American Wire Gage (Brown and Sharpe).

6. All feeder and branch circuit wiring shall be color-coded as follows:

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<th>PHASE</th>
<th>120/208 VOLT</th>
<th>277/480 VOLT</th>
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<tr>
<td>A</td>
<td>Black</td>
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<tr>
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<td>Red</td>
<td>Orange</td>
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<tr>
<td>C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>*White</td>
<td>*Grey</td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
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*Except as provided in paragraph 200.6 of the NEC.

C. ALUMINUM WIRE:

1. Aluminum conductors shall not be substituted for copper conductors.

D. CONNECTIONS

1. Wire connections shall be as follows unless otherwise indicated on the drawings.

a. Use preinsulated connectors 3M Company "Scotchlok," or Ideal Industries, Inc. "super nut," for splices and taps in conductors No. 10 AWG and smaller. All other
twist-on connectors must be reviewed by the Architect prior to installation. Use this type of connector for factory-made splices in fixtures or equipment.

b. Pressure indent type connectors must be submitted to the Architect for review.

c. Tape all splices and joints with vinyl plastic tape manufactured by Minnesota Mining and Manufacturing Company. Use sufficient tape to secure insulation strength equal to that of the conductors joined.

d. Keep splices in underground junction boxes to an absolute minimum. Where splices are necessary, use resin pressure splices and resin splicing kits manufactured by the 3M Company, St. Paul, Minnesota, to totally encapsulate the splice. Arrange the splicing kit to minimize the effects of moisture.

e. Connect wire No. 6 AWG and larger to panels and apparatus by means of approved lugs or connectors.

f. Connect wire No. 10 AWG and larger to panels, motors and electrical apparatus using OZ (or equivalent) type XL set screw type lugs. Lugs shall accommodate full wire capacity for stranded conductors. All connections and connectors shall be solderless.

g. Connectors of the porcelain cup type with or without metal inserts shall not be used, including all splices in fixtures which are made in advance by the fixture manufacturer. Splices in wire No. 8 AWG and larger shall be made with approved solderless lugs. If any type of pressure indent type connector is proposed for use on any size conductor, it shall be specifically submitted for approval prior to use.

3. EXECUTION

3.1 INSTALLATION

A. General: Install electric cables, wires and connectors as indicated in compliance with manufacturer’s written instructions, applicable requirements of the NEC and NECA’s "Standard of Installation", and in accordance with recognized industry practices.

B. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.

C. Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes. Junction boxes may be utilized wherever required.

D. Splicing: No splicing or joints will be permitted in either feeder or branch circuits except at outlet or accessible junction boxes.

E. Wire shall not be installed in raceways until the concrete work and plastering is completed and all conduits in which moisture has collected have been swabbed out. Insulation resistance to ground shall not be less than that approved by NEC. Eliminate splices wherever possible.
F. Use pulling compound or lubricant where necessary. Compound must not deteriorate conductor insulation.

G. Prior to energization, check cable and wire for continuity of circuitry, and for short circuits. Correct malfunctions when detected.

H. Bury a continuous, pre-printed, bright colored plastic ribbon cable marker with each underground cable, regardless of whether conductors are in conduit. Locate each directly over cables 12" below finished grade.

I. Conductor Installation: Install all conductors in a single raceway at one time, insuring that conductors do not cross one another while being pulled into raceway. Leave sufficient cable at all fittings or boxes and prevent conductor kinks. Keep all conductors within the allowable tension and exceeding the minimum bending radius.

J. Conductor Support: Provide conductor supports as required by the code and recommended by the cable manufacturer. Where required, provide cable supports in vertical conduits similar to OZ Type C.M.T., and provide the lower end of conduit with OZ Type KVF ventilators.

K. Conductor Termination: Provide all power and control conductors, that terminate on equipment or terminal strips, with solderless lugs or fork and flanged tongue terminals. Provide T and B "sta-kon" tongue terminal. This type conductor termination is not required when the equipment is provided with solderless connectors.

L. Many circuits are shown on the drawings to be provided with dedicated neutral and ground conductors. Carefully review circuiting and the electrical abbreviations and symbols legend and provide the number of conductors indicated.

M. Unless otherwise indicated provide dedicated neutral conductors for all branch circuits. Neutral conductors shall not be shared between circuits. Where the drawings indicate shared neutral conductors, for a multi-wire branch circuit, group the breakers together in accordance with NEC requirements.

3.2 CONDUCTOR ARCPROOFING

A. Cover two or more power feeder cables occurring in the same switchboard section, junction box or pull box (including pull boxes over switchboards) with arcproof and flameproof tape.

B. Provide 3M Company "Scotch" No. 77 tape or Plymouth Rubber Co. Slipknot No. 30 tape, to provide an installation capable of withstanding a 200-amp arc for not less than 30 seconds.
CONDUCTORS

END OF SECTION 26 05 19
SECTION 26 05 26 - GROUNDING SYSTEM

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. Division 26 “Basic Materials and Methods” sections apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. Extent of grounding work is indicated by the drawings and is specified herein.

B. Applications of grounding work in this Section include the following:

1. Underground Metal Piping
2. Underground Metal Water Piping
3. Metal Building Frames
4. Ground Rods
5. Separately Derived Systems
6. Service Equipment
7. Enclosures
8. Equipment

C. Requirements of this Section apply to electrical grounding work specified elsewhere in these specifications.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of electrical connectors, terminals and fittings, of types and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, ground rods and plate electrodes, whose products have been of satisfactory use in similar service for not less than three years.

B. Installer: Qualified with at least three (3) years experience on projects with electrical grounding work similar to that required for this project.

1.4 REFERENCES
A. **NEC Compliance:** Comply with NEC requirements as applicable to materials and installation of electrical grounding systems, associated equipment and wiring. Provide grounding products which are UL listed and labeled.

B. **UL Compliance:** Comply with applicable requirements of UL Standard Nos. 467 and 869 pertaining to electrical grounding and bonding.

C. **IEEE Compliance:** Comply with applicable requirements of IEEE Standard 142 and 241 pertaining to electrical grounding.

D. **Utility:** Grounding shall be done so as to comply with all applicable grounding requirements and rules of the serving utility.

E. **NECA Compliance:** Comply with NECA's "Standard of Installation."

1.5 **SUBMITTALS**

A. **Product Data:** Submit manufacturers data on grounding systems and accessories.

B. **Shop Drawings:** Submit layout drawings of grounding systems and accessories including, but not limited to, ground wiring, copper braid and bus, and ground rods.

2. **PRODUCTS**

2.1 **Acceptable Manufacturers:** Subject to compliance with the requirements, provide grounding products of one of the following:

A. **B-Line Systems**

B. **Burndy Corporation**

C. **Crouse Hinds**

D. **Electrical Components Div.; Gould Inc.**

E. **General Electric Supply Co.**

F. **Ideal Industries, Inc.**

G. **Thomas and Betts Corp.**
H. Western Electric Co.

2.2 Grounding Systems: Except as otherwise indicated, provide electrical grounding systems indicated; with assembly of materials, including but not limited to cables/wires, connectors, terminals, ground rods/electrodes, bonding jumper braid, and additional accessories needed for a complete installation. Where more than one type unit meets indicated requirements, selection is installer's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE and established industry standards for applications indicated.

2.3 Conductors: Unless otherwise indicated, provide electrical grounding conductors for grounding connections matching power supply wiring materials and sized according to NEC requirements.

2.4 Bonding Jumper Braid: Provide copper braid tape, constructed of 30 gage bare copper wires and properly sized for indicated applications.

2.5 Flexible Jumper Strap: Provide flexible flat conductor, 480 strands of 30 gage bare copper wire; 3/4" wide, 9-1/2" long; 48,250 cmil. Protect braid with copper bolt hole ends with hole sized for 3/8" dia. bolts.

2.6 Bonding Plates, Connectors, Terminals and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.

2.7 Ground Rods: Provide steel ground rods with copper welded exterior, 3/4" dia. x 10'.

2.8 Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, and bonding straps as recommended by accessories manufacturers for types of service indicated.

3. EXECUTION

3.1 GENERAL

A. Inspection: Installer must examine areas and conditions under which electrical grounding connections are to be made and notify the Architect/Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the installer.

B. General: Install electrical ground systems where shown, in accordance with applicable portions of the NEC, with NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.
C. Coordinate with other electrical work as necessary to interface installation of electrical grounding systems with other work.

D. Grounding and bonding of electrical installations and specific requirements for systems, circuits and equipment required to be grounded shall be accomplished for temporary and permanent construction.

E. Provide a separate green equipment ground conductor in all electrical raceways to effectively ground all fixtures, panels, receptacles, controls, motors, disconnect switches, exterior lighting standards and noncurrent carrying metal enclosures. The ground wires shall be connected to the building system ground. NEC Table 250-95 shall be used to size the ground conductor if the size is not shown on the drawings.

F. To satisfy the "effective grounding" requirements of the NEC the path to ground from circuits, equipment, and conductor enclosures shall be permanent and continuous and shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

G. Ground the service in accordance with provisions of the National Electrical Code and the contract drawings.

H. In addition to the requirements for service entrance grounding listed above, provide a supplemental grounding electrode consisting of driven ground rods (three 10 foot x 3/4 inch copper-clad steel ground rods).

I. Clean the contact surfaces of all ground connections.

J. Where separately derived systems occur, ground the system to a grounding electrode acceptable to the code.

K. Install metallic raceways mechanically and electrically secure at all joints and at all boxes, cabinets, fittings and equipment. At the point of electrical service entrance, bond all metallic raceways together, with a ground conductor, and connect to the system ground bus. Bond all boxes as specified for equipment.

L. Receptacles: Permanently connect the ground terminal on each receptacle to the green ground conductor.

M. Motors: Connect the ground conductor to the conduit with an approved grounding bushing, and to the metal frame with a bolted, solderless lug.

END OF SECTION 26 05 26
1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to electrical raceways specified herein.

1.2 DESCRIPTION OF WORK

A. Extent of raceways is indicated by drawings and schedules.

B. Types of raceways in this Section include the following:

1. Electrical metallic tubing.
2. Flexible metal conduit.
3. Intermediate metal conduit.
4. Liquid-tight flexible metal conduit.
5. Rigid metal conduit.
6. Rigid nonmetallic conduit.
7. Surface metal raceways.

1.3 REFERENCES

A. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

B. UL Compliance and Labeling: Comply with provisions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL-listed and labeled. Each length of raceway shall bear the Underwriters Laboratories label.

C. NEC Compliance: Comply with NEC requirements which are applicable to the construction and installation of raceway systems.

D. NECA Compliance: Comply with NECA's "Standard of Installation".

1.4 SUBMITTALS
A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations, for each type of raceway required.

2. PRODUCTS

2.1 STEEL CONDUIT

A. Steel Conduit: Rigid steel conduit, intermediate metal conduit and steel electrical metallic tubing shall be hot-dipped, galvanized or sheradized as manufactured by Youngstown Sheet and Tube Company, National Electric, General Electric, or equal.

B. Joints: Raintight non-insulated throat type compression fittings (connectors and couplings) shall be provided for electrical metallic tubing systems. All fittings shall be of the steel type with steel locknuts equal to Appleton 95 Series.

C. Expansion Joints: Provide expansion fittings, O.Z. Type AX with bonding jumper for rigid conduit and O.Z. Type TX with bonding jumper for electrical metallic tubing. Where embedded raceways cross building expansion joints, provide combination deflection/expansion fittings, O.Z. Type AXDX, or equal.

2.2 RIGID NON-METALLIC (PVC) CONDUIT

A. PVC (polyvinyl chloride) Conduit: Heavy wall rigid PVC conduit shall be composed of high impact PVC and shall conform to industry NEMA Standards and to Federal Specification WC-1094. Conduits shall be Carlon Schedule 40 type, or approved equal.

2.3 FLEXIBLE METAL CONDUIT

A. Flexible metal conduit shall conform to UL1. It shall be formed from continuous length of spirally-wound, interlocked zinc-coated strip steel.

B. Pre-wired armored cabling, types AC or MC are not allowed.

2.4 LIQUID-TIGHT, FLEXIBLE METAL CONDUIT

A. Liquid-tight flexible metal conduit shall be constructed of a single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; and coated with an oil-resistant, liquid-tight thermoplastic jacket.

2.5 WIREWAYS
A. General: Provide electrical wireways of types, grades, sizes, weights (wall thicknesses), and number of channels for each type of service indicated. Provide complete assembly of wireways including, but not necessarily limited to couplings, offsets, elbows, expansion joints, adapters, hold down straps, end caps, and other components and accessories as needed for a complete system. Where types and grades are not indicated, provide proper selection as determined by the Installer to fulfill wiring requirements and comply with applicable provisions of NEC for electrical raceways.

3. EXECUTION

3.1 GENERAL

A. Install electric raceways where indicated; in accordance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation" and complying with recognized industry practices.

B. Raceways embedded in concrete or in earth below floor slabs shall be rigid steel conduit, intermediate metal conduit or rigid schedule 40 PVC conduit. Rigid PVC conduit shall be provided with rigid metal or intermediate metal conduit elbows when the raceway system exits the concrete topping or earth.

C. Electrical metallic tubing shall not be embedded in concrete or installed in earth.

D. Rigid heavy wall Schedule 40 PVC conduit shall be installed in earth and concrete only.

E. Raceways in outside walls (excluding building perimeter) or in refrigerated areas shall be rigid steel conduit, or intermediate metal conduit.

F. Provide rigid steel conduit or intermediate metal conduit for exposed raceways from floor to eight feet above the floor in mechanical rooms and in areas designated on the plans.

G. Rigid galvanized steel conduit or galvanized intermediate metal conduit shall be used where conduit is exposed to weather.

H. **Rigid galvanized steel and cast boxes with external hubs shall be used to serve electrical devices located within the Bio Safety Level 3 (BSL3) barrier.**

I. Conduits in hazardous locations shall conform to the National Electrical Code. Rigid galvanized steel conduit or intermediate metal conduit shall be used in hazardous locations. PVC conduit shall not be used in hazardous areas.
J. Rigid metal, intermediate metal, electric metallic tubing or PVC conduit where allowed in other section 3.1 paragraphs shall be used for feeders and branch circuits.

K. Flexible metal conduit may be used to connect light fixtures in accordance with NEC requirements but must be limited to a maximum of 6'-0" in length. “Daisy chaining” from fixture to fixture is not permitted. Provide flexible metal conduit for connections to motors, transformers, generators, and other equipment subject to vibration. Length of flexible conduit shall be a minimum of one foot for conduit diameters up to 1-1/2". A minimum of 3" of flexible conduit shall be added for every 1/2" increase in conduit diameter. Flexible metal conduit installation shall be kept to a minimum in connecting other electrical equipment items. Seal tight, flexible conduit shall be used where the flexible conduit may be subject to moist or humid atmosphere, corrosive atmosphere, subject to water spray and subject to dripping oil, grease or water. **Flexible metal conduits shall not be permitted for any other applications, unless specifically approved by the Owner**

L. Conduits shall be 3/4" diameter, minimum. Raceway sizes shown on the drawing are based on type THHN/THWN conductors.

M. Type Material: Except as noted otherwise all conduit shall be steel.

3.2 INSTALLATION

A. All raceways shall be installed concealed except where shown or noted otherwise.

B. At the Owner’s option, concealed raceways may be embedded in concrete or routed below the slab. At the Contractor's option, concealed raceways may be installed in furred spaces above ceilings or behind walls.

C. Continuity: Provide metallic raceways continuous from outlet to outlet, and from outlets to cabinets, junction or pull boxes. Enter and secure conduit to all boxes to provide electrical continuity from the point of service to outlets. Provide double locknut and bushing on terminals of metallic conduits.

D. A nylon or polypropylene pull string shall be installed in all empty conduits to facilitate future installation of cabling.

E. Provide accessible "seal-off" fittings for all raceways entering or leaving the **BSL3 Barrier**, hazardous areas, entering or leaving refrigerated areas and as otherwise required by the National Electrical Code.

F. Where conduits penetrate the roof seal, they shall be installed in curbs provided for mechanical equipment. When this is not possible, suitable pitch pockets, lead flashing, or approved fittings shall be provided. Details for special conduit installations shall be as shown on the drawings.
G. Reinforced Concrete: No reinforcing steel shall be displaced to accommodate the installation of raceways and outlet boxes. Outlet boxes shall not be installed in beams or joists. In general, all embedded conduits shall be located in the physical center of the particular section of concrete. Unless otherwise indicated, raceways embedded in reinforced concrete shall conform to the following usual types of conditions. Particular attention is called to the fact that there are many extenuating conditions where the Contractor may be instructed in writing during the course of the project not to place embedded conduits in certain areas, generally due to the possibility of unsightly cracking or for structural reasons. This instruction shall not entitle the Contractor to extra compensation. Any condition not covered by the following usual conditions shall require special clarification.

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Columns</td>
<td>Displacement of 4 percent of plan area of column.</td>
</tr>
<tr>
<td>2. Floors and Walls</td>
<td>Displacement of 1/3 of thickness of concrete spaced not less than three diameters on center.</td>
</tr>
<tr>
<td>3. Beams and Joists</td>
<td>Displacement of 1/3 of least dimension, spaced not less than three diameters on center.</td>
</tr>
<tr>
<td>4. Sleeves thru Floors and Walls</td>
<td>2” maximum pipe size, not less than three diameters on center.</td>
</tr>
</tbody>
</table>

H. Plain Concrete: Raceways shall not be placed in plain concrete, such as cement toppings on structural floors without special instructions.

I. Furred Spaces: Raceways installed in furred spaces shall be installed in accordance with the requirements of the National Electrical Code. Do not anchor or strap conduits to the ceiling furring channels or attach to furred ceiling hanger wires. Raceways may be attached to the suspension system (wire hangers) of drop ceilings if installed in such a manner that the ceiling panels may be removed without interference with the raceway, and the wire hangers are sized to carry the additional raceway load.

J. Stub Ups: Extend conduit stubs at least one foot above slab or fill, before connection is made to electrical metallic tubing.

K. Exterior Conduits: Install raceways a minimum of 42” below finished grade unless noted otherwise on the drawings.

L. Provide marking of conduit and junction boxes to indicate which distribution system they are serving. The markings could be colored tape on conduit at or near junction boxes with different colored tapes indicating different distribution systems. Concealed junction boxes shall be legibly marked with a magic marker to indicate the panel and circuit number that junction box serves.

1. The distribution systems shall be color coded as follows:
a. Fire Alarm - Red
b. 120/208 Volt - Green
c. 277/480 Volt - Orange
d. Cable TV System - Black
e. Telephone System - White

M. Steel Conduit (galvanized rigid steel, IMC or EMT):

1. Cutting: Cutting shall be done with hand or power hacksaws. All cut ends shall be reamed to remove burrs and sharp edges.
2. All threaded joints shall be made up wrench-tight and all compression joints shall be made up mechanically secure and snug so as to make continuous current-carrying electrical contact.
3. All metallic conduits buried or otherwise in contact with earth shall be painted using one heavy continuous coat of asphalt varnish after assembly of conduit and fittings.
4. Expansion joints shall be installed in steel conduit systems in structures as follows (expansion joints are specified elsewhere in the specification):
   a. Where conduit run crosses a building expansion joint.
   b. In any conduit run exceeding 100 feet in length.
   c. Where shown on the drawings.

N. Threads: Clean all threads of rigid or intermediate metal conduit. Coat all male threads of all steel conduit installed in concrete with red or white lead immediately before being coupled together.

O. Running Threads: Use "Erickson" type couplings in lieu of running threads.

P. PVC Conduit:

1. Joints: Conduits shall be joined by using couplings and solvent cement furnished or recommended by the raceway manufacturer. Finished joints shall be secure and watertight.
2. Cutting: Cutting shall be done with hacksaws and ends shall be reamed to remove burrs and sharp edges.
3. Expansion Joints: Expansion joints shall be installed:
   a. Where conduit run crosses a building expansion joint.
   b. As recommended by the manufacturer or as shown on the drawings.
4. Bends for PVC conduit sizes 2" and smaller may be made "hot" in the field. Inside dimension shall be thereby undistorted. For PVC sizes larger than 2", provide only factory bends.
SECTION 26 05 73 – LOW VOLTAGE ELECTRICAL SYSTEMS STUDIES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The scope of this section is to provide requirements for low voltage (600 volts and below) studies and documentation. This includes short circuit analysis with equipment evaluation, overcurrent protective device coordination, and arc flash analysis.

2. EXECUTION

2.1 SUBMITTALS

A. A coordination study shall be provided by the contractor for this project. The study shall include maximum short circuit calculations, a complete coordination analysis, and settings for all protective devices with adjustable set points. The protective device settings must address the need to minimize arc flash hazards while maintaining proper system coordination. The coordination study shall be based on the specific devices installed and include (but not be limited to) the following:

1. Service Entrance Equipment.
   a. All overcurrent protective devices installed in service entrance panels/switchboards.

2. Feeder Circuits.
   a. All three (3) phase feeder circuit overcurrent protective devices.

   a. All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   b. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

4. Motor Control Centers
   a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

5. Format
a. The preliminary coordination study should be submitted to the Owner’s Representative no later than six (6) weeks after overcurrent protective device shop drawings have been reviewed.

b. The coordination study shall be reviewed and updated to reflect any changes within one week of the final electrical walk through for project.

c. The low voltage coordination study shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed by the Engineer of Record.

d. A complete set of manufacturers’ descriptive literature and detailed instructions for adjusting overcurrent protective devices shall be provided to the Owner’s Representative within six (6) weeks after overcurrent protective device shop drawings have been approved.

e. The low voltage coordination study shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32).

f. Prior to project completion, the low voltage coordination study shall be provided to the Owner’s Representative in both hard copy and on computer disk. The hard copy shall include time current curves (for phase and ground fault settings) for each panel and the corresponding TCC report clearly showing each device set point. The computer disk shall include the complete coordination file including all device curves (use the SKM “Project - Backup” command).

B. All overcurrent protective devices feeding the emergency system(s) shall be selectively coordinated in accordance with the applicable version of NEC.

C. A low voltage Arc Flash Hazard Analysis shall be provided by the contractor for this project. The analysis shall be based on the specific equipment installed, and shall be updated to include project “as built” documentation. The Arc Flash Hazard Analysis shall utilize owner’s existing SKM study for the existing portion of the electrical distribution and shall be updated/expanded for all new equipment installed under this project’s scope of work. Coordinate with owner. Where the arc flash hazard/risk category is equal to or greater than level 3, the overcurrent protective device coordination study shall be reviewed and recommendations shall be provided to reduce the hazard/risk level. The analysis shall be based on the specific devices installed and include (but not be limited to) the following:

1. Service Entrance Equipment.

   a. All overcurrent protective devices installed in service entrance panels/switchboards.

2. Feeder Circuits.

   a. All three (3) phase feeder circuit overcurrent protective devices.


   a. All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
b. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.


a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

5. The project shall include printed waterproof labels for equipment that lists the specific arc flash hazard/risk category at each location.

6. Format

a. A preliminary Arc Flash Hazard Analysis should be submitted to the Owner’s Representative no later than six (6) weeks after the overcurrent protective device shop drawings have been reviewed.

b. The Arc Flash Hazard Analysis shall be reviewed and updated to reflect any changes and corrections to conductor length within one week of the final electrical walk through for the project.

c. The low voltage arc flash hazard analysis shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed by the Engineer of Record.

d. Owner approved Arc Flash Hazard warning labels shall be furnished and installed prior to project completion.

e. The low voltage arc flash hazard analysis shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32).

f. Prior to project completion, the low voltage arc flash hazard analysis shall be provided to the Owner’s Representative in both hard copy and on computer disk. The hard copy shall clearly show each device set point. The computer disk shall include the complete coordination file including all device curves (use the SKM “Project - Backup” command).

END OF SECTION 26 05 73
PART 1 - GENERAL

1.1. DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process which are being directed by the CxA.

B. The systems to be commissioned are listed in Section 01 91 00 Part 1.11.

C. Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 26 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2. RESPONSIBILITIES

A. Electrical Contractors. The commissioning responsibilities applicable to the electrical contractor are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.

2. Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment.

3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.
   a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner/using agency-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner/Using Agency to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.
   b. The Commissioning Authority may request further documentation necessary for the commissioning process.
   c. This data request may be made prior to normal submittals.

4. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

5. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

6. Provide assistance to the CxA in preparation of the specific functional performance test procedures specified. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

7. Develop a full start-up and initial checkout plan using manufacturer’s start-up procedures and the prefunctional checklists from the CxA for all commissioned equipment. Submit to CxA for review and approval prior to startup. Refer to Section 01 91 00 Part 3.4 for further details on start-up plan preparation.

8. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CxA for all commissioned equipment.
SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL SYSTEMS

9. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

10. Address current A/E punch list items before functional testing.

11. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

12. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, CM and A/E and retest the equipment.

13. Prepare O&M manuals according to the Contract Documents.

14. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

15. Provide training of the Owner/Using Agency’s operating staff using expert qualified personnel as specified.

16. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Electrical Designer/Engineer

1. Refer to Section 01 91 00 or the responsibilities of the Electrical Designer/Engineer.

1.3. RELATED WORK

A. Refer to Section 01 91 00 Part 1.8 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 Part 1.11 for systems to be commissioned and Section 01 91 00 Part 3.6 for functional testing requirements.

PART 2 - PRODUCTS

2.1. TEST EQUIPMENT

A. Division 26 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 Part 2.1 for additional Division 26 requirements.

PART 3 - EXECUTION

3.1. SUBMITTALS

A. Division 26 shall provide submittal documentation relative to commissioning equipment and systems as required in this Section Part 1, Section 01 33 00 Construction Submittal Procedures and Section 01 91 00 Part 3.3.

3.2. STARTUP

A. The electrical contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 00 Part 3.4. Division 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning Authority or Owner/Using Agency.
B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CxA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3. FUNCTIONAL PERFORMANCE TESTS
   A. Refer to Section 01 91 00 Part 1.11 for a list of systems to be commissioned and to Part 3.6 for a description of the process.

3.4. TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS
   A. Refer to Section 01 91 00 Part 3.4 for specific details on non-conformance issues relating to prefunctional checklists and tests.
   B. Refer to Section 01 91 00 Part 3.7 for issues relating to functional performance tests.

3.5. OPERATIONS AND MAINTENANCE (O&M) MANUALS
   A. The following O&M Manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.
   B. Division 26 shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver to the GC for inclusion in the O&M manuals, according to this Section, prior to the training of Owner/Using Agency personnel.
   C. The CxA shall receive a copy of the O&M manuals for review.

3.6. TRAINING OF OWNER/USING AGENCY PERSONNEL
   A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 Part 3.9 for additional details.
   B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner/Using Agency personnel for commissioned equipment. Refer to Section 01 91 00 Part 3.9 for additional details.
   C. Electrical Contractor. The electrical contractor shall have the following training responsibilities:
      1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00 Part 3.9.
      2. Provide designated Agency personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
      3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
      4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
      5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
      6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
      7. Training shall include:
SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL SYSTEMS

a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.

b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

c. Discuss relevant health and safety issues and concerns.

d. Discuss warranties and guarantees.

e. Cover common troubleshooting problems and solutions.

f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.

g. Discuss any peculiarities of equipment installation or operation.

h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1.1-2007 is recommended.

i. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut down and any emergency procedures and maintenance of all pieces of equipment.

9. The Electrical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

11. Duration of Training. The electrical contractor shall provide training on each piece of equipment listed in the following schedule. This list is not meant to be all inclusive but is to provide a representative example of the level of training required by the electrical contractor. Electrical contractor shall assign hours to each type of equipment/system and submit completed comprehensive list and schedule to CxA and Owner/Using Agency for review prior to implementation.

<table>
<thead>
<tr>
<th>Hours</th>
<th>System</th>
<th>Hours</th>
<th>System</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lighting controls and systems (interior and exterior)</td>
<td>Security system (access control system)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical power systems (medium &amp; low voltage, power quality &amp; control systems)</td>
<td>Fire alarm and smoke detection system</td>
<td></td>
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<tr>
<td></td>
<td>Telecommunications cabling systems (interior and exterior)</td>
<td>Overhead doors with automatic operators</td>
<td></td>
</tr>
</tbody>
</table>

3.7. DEFERRED TESTING
A. Refer to Section 01 91 00 Part 3.10 for requirements of deferred testing.

3.8. WRITTEN WORK PRODUCTS
A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 Part 3.11 and the filled-out start-up, initial checkout and prefunctional checklists.

END OF SECTION 26 08 00
SECTION 26 22 00 - DRY-TYPE TRANSFORMERS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Extent of transformer work is indicated by drawings and schedules.

B. Types of transformers specified in this Section include the following:
   1. Energy Efficient Dry-type Transformers

C. Refer to other Division 26 sections for electrical wiring connections required in conjunction with transformers; not work of this Section.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of power distribution transformers of types and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer: Qualified with at least three (3) years successful installation experience on projects with electrical power/distribution transformer work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to installation and construction of electrical power/distribution transformers.

B. NEMA Compliance: Comply with applicable portions of the NEMA Std. Pub. Nos. TR1 and TR27 pertaining to power/distribution transformers.

C. ANSI Compliance: Comply with applicable ANSI standards pertaining to power/distribution transformers.

D. ANSI/IEEE Compliance: Comply with applicable ANSI/IEEE standards pertaining to power/distribution transformers.

E. ANSI/NEMA Compliance: Comply with NEMA Std. ST 20 "Dry-Type Transformers for General Applications".
F. ANSI/UL Compliance: Comply with applicable portions of ANSI/UL 506 "Safety Standard for Specialty Transformers".

G. UL Labels: Provide distribution transformers that have been UL listed and labeled.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data including KVA rating, frequency, primary and secondary voltages, percent taps, impedance and certification of transformer performance efficiency at indicated loads, no load and full load losses in watts, hot spot and average temperature rise above 40 degrees C ambient, sound level in decibels, and standard published data.

B. Shop Drawings: Submit manufacturer's drawings indicating dimensions and weight loading for transformer installations.

2. PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of transformer):

A. Cutler Hammer
B. General Electric Co.
C. Square D Co.
D. Siemens

2.2 EQUIPMENT

2.3 Furnish and install dry-type transformers as shown on the drawings.

A. Transformer coils shall be of the continuous copper wound construction.

B. All transformer cores shall be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.

C. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.

D. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of
degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

E. Dry-type transformers shall have metallic enclosures designed to provide for air cooling and to prevent accidental contact with live conductors. Materials and final performance of the product must conform to applicable IEEE and NEMA standards. Transformer wiring compartment shall be located below the core and coil, and shall be cooled by air circulation, or the wiring compartment shall be insulated from the core and coil by means of a suitable thermal insulation barrier. All transformers shall be UL listed and shall bear the UL label.

F. Transformers shall operate at 100% nameplate KVA rating continuously while in a 40 degrees C ambient environment without exceeding the rated average winding temperature rise of the ANSI insulated system used. Specific KVA and voltage ratings required shall be as shown on the drawings. Transformers rated above 30 KVA shall have a 220 degrees C insulation system with 115 degrees C average temperature rise. Transformers rated 30 KVA and below shall have a 220 degrees C insulation system with 115 degrees C average temperature rise.

G. Sound levels must fall within ANSI-NEMA Standard levels according to KVA size.

H. Sound levels shall be warranted by the manufacturer not to exceed the following:

   1. 15 to 50KVA - 45dB; 51 to 150kVA - 50dB; 151 to 300kVA - 55dB; 301 to 500kVA - 60dB; 501 to 700kVA - 62dB; 701 to 1000kVA - 64dB; 1001 to 1500kVA - 65dB; 1501 to 2000kVA- 66Db.

I. All transformers shall be supplied with clamp-type solderless connectors suitable for use with copper connecting cables.

J. All transformers shall have neoprene rubber pads between the core and coil assembly and the transformer enclosure to isolate sound and vibration. A flexible conduit connection to the transformer may be used.

K. Terminal boards shall be provided on all transformers. High-voltage and low-voltage terminals must be held in a fixed position, thus removing any need for taping of cable-terminal connections.

L. Transformers which weigh more than 50 pounds must have external lifting provisions for ease in handling.

M. Single phase transformers over 10 KVA and three-phase transformers 6 KVA and above shall have minimum full load rated taps in the high-voltage windings as follows: four 2-1/2% full capacity taps, 2 above and 2 below normal rated voltage. Transformer taps shall be adjusted to deliver nominal system voltage at branch circuit panels.
3. **EXECUTION**

3.1 Install transformers as indicated in compliance with the manufacturers’ written instructions, applicable requirements of the NEC, NEMA, ANSI and IEEE standards, and in accordance with recognized industry practices to ensure that products fulfill requirements.

3.2 Coordinate transformer installation work with electrical raceway and wire/cable work, as necessary for proper interface.

3.3 Install transformers on vibration mounts; comply with manufacturers recommended installation methods, if applicable.

3.4 Clearances shall be maintained around transformers in accordance with all applicable codes, standards and manufacturer’s installation instructions.

END OF SECTION 26 22 00
SECTION 26 24 16 - PANELBOARDS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract including General and Supplementary Conditions and Division 1 specification sections, apply to the work of this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to panelboards specified herein.

1.2 DESCRIPTION OF WORK

A. Extent of panelboard and enclosure work, including cabinets and cutout boxes is indicated on the drawings and by schedules.

B. Types of panelboards and enclosures in this Section include the following:

   1. Distribution Panels
   2. Lighting and Appliance Panels
   3. Transient Voltage Surge Suppression (TVSS or SPD) Panels

C. Refer to other Division 26 sections for cable/wire, connectors and electric raceway work required in conjunction with panelboards and enclosures; not work of this Section.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of panelboards and enclosures, of types, size and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer: A firm of at least three (3) years of successful installation experience on projects with electrical installation work similar to that required for this project.

1.4 REFERENCES

A. Special Use Markings: Provide panelboards, constructed for special use, with UL markings indicating that special type usage. Panels identified or shown on the drawings for use as main service entrance equipment shall be labeled at the factory with "SERVICE ENTRANCE" type UL label.
B. UL Compliance: Comply with applicable UL safety standards pertaining to panelboards, accessories, and enclosures. Provide units which have been UL listed and labeled. UL standards are as follows:

1. Panelboards - UL67
2. Cabinets and Boxes - UL50

C. NEC Compliance: Comply with the NEC as applicable to the installation of panelboards, cabinets, and cutout boxes.


E. NECA Compliance: Comply with NECA's "Standard of Installation".

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations for each panelboard required. Include data substantiating that units comply with specified requirements.

B. Shop Drawings: Submit dimensioned drawings of panelboards and enclosures showing accurately scaled layouts of enclosures and required individual panelboard devices, including but not limited to circuit breakers, fusible switches, fuses, ground fault circuit interrupters, and accessories.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements provide products of one of the following:

1. Square D Company
2. General Electric
3. Cutler Hammer
4. Siemens

2.2 FEEDER PROTECTIVE DEVICE COORDINATION

A. All overcurrent protective devices feeding the emergency system(s) shall be selectively coordinated in accordance with the NEC.
2.3 GENERAL

A. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials, and which are designed and constructed in accordance with published product information. Provide solderless lugs, or connectors, in the correct number and size for conductors on mains, on the load side of each branch, circuit, and on ground and neutral bars. Provide tin plated copper busses. Provide an insulated neutral bus and a bonded equipment ground bus mounted at the opposite end of the structure from the mains, and having numbered screw or lug terminals for connection of wires. Equip panels with the number of unit devices as required for a complete installation. Where more than one type of component meets the indicated requirements, selection is installer's option. Where types, sizes or ratings are not indicated, comply with NEC, UL and established industry standards for applications indicated.

B. Provide ground fault circuit interrupting type circuit breakers for all devices noted with a "GFI" subscript on the panelboard schedules for this project.

C. Provide UL listed HACR type circuit breakers for all devices which serve heating, ventilating, or air conditioning equipment.

D. Panelboards shall be provided with covers for surface or flush mounting as shown on the drawings, or as required for actual project conditions.

E. Panelboards shall be constructed for top or bottom feeder service, as required by actual project conditions.

2.4 LIGHTING AND APPLIANCE PANELS

A. Lighting and appliance panelboards shall be Square D type NF (or equal) for 277/480 volt or Square D type NQOB (or equal) 120/208 volt applications. All branch circuit breakers are to be quick-make, quick-break, trip indicating and common trip on all multi-pole breakers, and shall be bolt-on type. Trip indication shall be clearly shown by breaker handle located between the "ON" and the "OFF" positions. Panelboards shall have distributed phase copper bussing throughout.

B. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.

C. Provide fully rated main circuit breaker or main lug only (see drawings) type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.

D. Lighting and appliance panels shall be 5.75” deep, maximum and shall have 6-inch minimum gutters. Fronts are to be complete with door and cylinder lock, with all locks keyed alike. Fronts
shall have adjustable trim clamps, directory frames, and shall be equipped with a typewritten directory that identifies each circuit breaker by number and the equipment that the breaker serves. One additional blank directory card for each panel shall be furnished to the Owner.

E. Two section panels (as required by Code) shall be equipped with boxes of equal dimensions.

F. Panelboards shall be Underwriters' Laboratory listed and shall bear the UL label. The size of the panelboard main disconnect device or main lugs, the rating and number of branch circuits, and the type of mounting shall be as shown on the drawings.

G. All factory installed devices shall be re-torqued prior to energizing.

2.5 DISTRIBUTION PANELS

A. Distribution panels shall be Square D I-Line (or equal) panels as indicated on the plans. Provide appropriate type of panels to meet specific project requirements. Panelboards shall have distributed phase copper bussing throughout.

B. Circuit breakers shall be as specified for lighting panels unless indicated otherwise. Power panels shall have combination card holder and name-plate and shall be equipped with typewritten directories that identify all loads served and all spare circuits. Provide a copper ground bus in all power panels.

C. Power panels shall be Underwriters' Laboratory approved and shall bear the UL label. Main lugs and gutters shall be suitable for copper and aluminum wire. The size of the panelboard main protective device or main lugs, the size, type and the number of branch circuits and the type of mounting shall be as shown on the drawings.

D. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.

E. Provide fully rated main circuit breaker or main lug only (see drawings) type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.

2.6 FEEDER PROTECTIVE DEVICES

a. Feeder protective devices as shown shall be molded case air circuit breakers, built, tested and UL labeled per UL 489.

b. In general 100 ampere through 400-ampere frames shall be thermal-magnetic trip with inverse time current characteristics. Breakers with 225 ampere through 400-
ampere frames shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.

c. In general breakers with 600 ampere frames and above shall be Square D Powerpact or approved equivalent with solid-state trip complete with built in current transformers, solid-state trip unit and flux transfer shunt trip. Breakers shall have easily changed trip-rating plugs with trip ratings as indicated on the drawings. Rating plugs shall be interlocked so they are not interchangeable between frames and interlocked such that breakers cannot be latched with rating plug removed. Breaker shall have built-in test points for testing long delay, instantaneous and ground fault (where shown). Functions of the breaker shall be tested by means of a 120 volt operated test kit. Provide one test kit capable of testing all breakers 600 ampere and above.

d. Solid state instantaneous element shall be continuously adjustable from approximately 4 to 8 times the trip rating, with short time adjustment from instantaneous to 10-cycle delay for coordination purposes. Provide short delay override feature providing for instantaneous tripping on high magnitude faults.

e. Molded case breakers shall have a minimum UL listed interrupting capacity as listed on the drawings.

f. Breakers 2000 thru 3000A frame on the drawings shall be UL listed and labeled for 100 percent application per the N.E.C.

g. For all circuit breakers rated 1200 Amps or more, provide circuit breaker with an energy reducing maintenance switch per NEC paragraph 240.87

2.7 CUSTOMER METERING

A. Where indicated on the drawings, provide digital electronic power meters with the following monitoring and metering capabilities:

1. Current, per phase and neutral.
2. Voltage, phase-to-phase and phase-to neutral.
3. Real power (kW), per phase and three-phase total.
4. Reactive power (kVAR), per phase and three phase total.
5. Apparent power (kVA), per phase and three phase total.
6. Power factor (true), per phase and three phase total.
7. Frequency.
8. Demand current, per phase and neutral, present and peak.
9. Real power demand (kWd), three phase total, present and peak.
10. Reactive power demand (kVARD), three phase total, present and peak.
11. Apparent power demand (kVAd), three phase total, present and peak.
12. Real energy (kWh), three phase total.
13. Reactive energy (kVARh), three phase total.
14. Apparent energy (kVAh) three phase total.
15. Energy accumulation modes, signed, absolute, energy in, energy out.
16. Total harmonic distortion (THD), voltage and current, per phase.
17. Date and time stamping, peak demands, power up/restart and resets.
B. The power meter shall be accurate to 0.25% of the reading plus 0.05% of the full scale for voltage and current sensing, and 0.5% of the reading plus 0.05% of the full scale for power and energy, accurate through the 31st harmonic.

C. Provide necessary current transformers to support current inputs to the power meter. Provide potential transformers, control power transformers, and fusing as required.

2.8 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS or SPD) PANELS

A. Transient voltage surge suppression (TVSS or SPD) panels shall be designed for non-linear loads incorporating transient voltage surge suppression and high-frequency electrical line noise filtering connected in parallel with the facility's wiring system. The specified unit shall be suitable for non-linear loads and shall provide effective high-energy transient voltage suppression, surge current diversion, high-frequency electrical line noise attenuation, and line control in ANSI/IEEE C62.41-1991 environments when connected downstream from the facility's main overcurrent device. Comply with all requirements of this specification for lighting and appliance and distribution panels.

B. The manufacturer of the unit must have been engaged in the design and manufacture of such products for a minimum of five years.

C. The specified unit shall be designed, manufactured, tested and installed in compliance with the latest edition of the following standards:

1. ANSI/IEEE C62.41, C62.45
2. FIPS PUB 94
3. NEMA LS-1
4. NFPA 70, 75 and 78
5. UL 50, 67, 489, 943, 1283 and 1449.

D. The unit shall be UL 1449, second edition listed as a transient voltage surge suppression unit.

E. Environmental Requirements

1. Operating temperature range shall be -40 degrees to +60 degrees C.
2. Operation shall be reliable in an environment with 5% to 95% non-condensing relative humidity.
3. The unit shall not generate audible noise greater than 35 dB at 3 feet from the unit.
4. No appreciable magnetic fields shall be generated. The unit shall be capable of use directly in computer rooms in any location without danger to data storage systems or devices.

F. Electrical Requirements
1. The nominal unit operating voltage and configuration shall be as indicated on the drawings.
2. The maximum continuous operating voltage of all suppression components utilized in the unit shall not be less than 115% of the facility's nominal operating voltage.
3. The operating frequency range of the unit shall be 47 to 63 Hertz.
4. The unit's primary mode of protection shall be line-to-neutral. The secondary modes of protection shall be line-to-ground and neutral-to-ground.
5. Based on ANSI/IEEE C62.41-1991's standard 8 x 20 microsecond current waveform, the maximum repetitive surge current capacity, in amps, of the unit shall be no less than 100 KA per mode.
6. The unit’s published performance ratings shall be the UL 1449 Listed suppression ratings. The UL 1449 suppression rating shall be, for each mode of protection and system voltage as follows:
   a. L-L: 1500 Volts for 480Y/277 Volt, 3 phase, 4 wire systems, 700 Volts for 208Y/120 Volt, 3 phase, 4 wire systems and 240/120 Volt 1 phase, 3 wire systems.
   b. L-N: 800 Volts for 480Y/277 Volt 3 phase, 4 wire systems, 400 Volts for 208Y/120 Volt 3 phase, 4 wire systems and 240/120 Volt 1 phase, 3 wire systems.
   c. L-G: 1500 Volts for 480Y/277 Volt 3 phase, 4 wire systems, 700 Volts for 208Y/120 Volt 3 phase, 4 wire systems and 240/120 Volt 1 phase, 3 wire systems.
   d. N-G: 800 Volts for 480Y/277 Volt 3 phase, 4 wire systems, 400 Volts for 208Y/120 Volt 3 phase, 4 wire systems and 240/120 Volt 1 phase, 3 wire systems.

G. Documentation and Testing

1. The manufacturer shall furnish an equipment manual with installation, operation and maintenance instructions for the specified unit.
2. Documentation of the unit's UL 1449 suppression rating shall be included as required product data submittal information. Manufacturer shall make available upon request certified documentation of applicable Location Category Testing in full compliance with ANSI/IEEE C62.41-1991 and ANSI/IEEE C62.45-1987 guidelines.
3. A list of customer-replaceable spare parts shall be included in the unit's installation, operation and maintenance instructions. All spare parts shall be quickly and easily field-replaceable.
4. The TVSS device repetitive surge current capacity shall be tested utilizing a 1.2 x 50 microsecond waveform as defined by ANSI/IEEE 62.41-1991 and ANSI/IEEE 62.45-1992 at one minute intervals. A failure is defined as either performance degradation or more than 10% deviation of clamping voltage at the specified surge current. The device shall be capable of surviving 5000 impulses without failure or performance degradation.
5. The unit shall be factory tested and burned in at the applicable MCOV for a minimum of one hour.
6. The unit shall be provided with a five-year warranty.
7. The unit shall be thoroughly factory-tested before shipment. Testing of each unit shall include but shall not be limited to quality assurance checks, MCOV and clamping voltage verification tests.
H. Construction

1. Panel trim, box, interior, bus and circuit breakers shall be as specified for lighting and appliance panels and on the drawings. The TVSS shall be mounted integral to the panelboard equipment and shall not violate the equipment manufacturer’s UL label.

I. Suppression/Filter System

1. The unit shall include an engineered solid-state high-performance suppression system, utilizing arrays of fused non-linear voltage dependent metal oxide varistors with similar operating characteristics. The suppression system’s components shall optimally share surge currents in a seamless, low-stress manner assuring maximum performance and proven reliability. The suppression system shall not utilize gas tubes, spark gaps, silicon avalanche diodes or other components which might short or crowbar the line, thus leading to interruption of normal power flow to or system upset of connected loads. The suppression system shall not incorporate any other components which may degrade performance or reliability of the suppression system.

2. The fusing system shall be capable of allowing the rated maximum surge current to pass through without fuse operation. Systems utilizing a fusing system that opens below the maximum surge current level are unacceptable.

3. The unit shall include an EMI/RFI noise suppression filter capable of a minimum of –40 dB attenuation at 100 kHz.

4. Any TVSS unit mounted in a distribution panel shall have an integral disconnect or circuit breaker to be used as a means of disconnecting the suppression/filter system for maintenance and/or test purposes without interruption of power to the facility's distribution system.

5. All internal wiring associated with the suppression/filter system and subject to surge currents shall utilize low-impedance copper bus bar and/or #8 AWG copper conductor or larger. All internal connections associated with the suppression/filter system and subject to surge currents shall be made with compression solderless-type lugs and shall be bolted to the bus bars in order to reduce overall system impedance. No plug-in component modules, quick-disconnect terminals or printed circuit boards shall be used in surge current-carrying paths.

6. The unit shall include the following accessories:
   
   a. The unit shall include Form C dry contacts (N.O. and N.C.) to facilitate connection to a building management system in order to monitor the on-line status of the unit. The contacts shall be normally open or normally closed and shall close or open upon failure of the suppression system and/or fuse.

   b. Operational status indicating lights.

   c. Audible alarm and alarm indicating light.

   d. Transient Voltage surge counter with battery backup.

3. EXECUTION
3.1 INSTALLATION

A. General: Install panelboards and enclosures where indicated, in accordance with the manufacturers' written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Coordinate the installation of panelboards and enclosures with cable and raceway installation work.

C. Provide all required electrical connections within the enclosure.

D. Fill out typewritten panelboard circuit directory cards upon completion of the installation work.

END OF SECTION 26 24 16
SECTION 26 25 50 – ROTARY GENERATOR DOCKING STATION

1. GENERAL

1. QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

2. GUARANTEE/WARRANTY

A. The equipment installed under this contract shall be left in proper working order.

B. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

2. PRODUCTS

1. Rotary Generator Docking Station

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. TRYSTAR: GDR --- TRYSTAR, info@trystar.com

2. GENERAL REQUIREMENTS

A. Rotary Manual Transfer Switch:

1. Docking Station shall have integrated Rotary Manual Transfer Switch (MTS).
   a. MTS shall be three positions. Utility-Off-Generator.
   b. MTS shall be located behind pad lockable door to prevent any tampering by unauthorized personnel.

B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.

C. Enclosures:

1. NEMA 3R rain-tight, aluminum enclosure.
a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or portable load bank. NEMA 3R integrity shall be maintained with access plate open for cable entry.

b. Front, and side through a front access panel shall be accessible for maintenance.

c. Top, side, and back through a front access panel shall be accessible for permanent cabling.

2. Finishes:

D. Phase, Neutral, and Ground Buses:

1. Material: Silver-plated
2. Equipment Ground Bus: bonded to box.
3. Isolated Ground Bus: insulated from box.
4. Ground Bus: 50% of phase size.
5. Neutral Bus: Neutral bus rated 100 percent of phase bus.
6. Round edges on bus.

E. Portable generator connectors shall be Camlok style mounted on gland plate.

1. Camlok shall be color coded according to system voltage
   a. A phase – Brown or Black
   b. B phase – Orange or Red
   c. C phase – Yellow or Blue
   d. N Neutral – White
   e. G Ground – Green

F. Permanent connectors shall be broad range set-screw type, located behind an aluminum barrier.

G. Voltage & Amperage shall be as shown on project one line drawing. Camloks shall be color coded as appropriate for the specified voltage.

3. EXECUTION

1. EXAMINATION

A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.

2. INSTALLATION

A. Surface, Flush or Base Mounted: Determined by Application
   1. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.
3. FIELD QUALITY CONTROL

A. Third Party Tests and Inspections to include the following:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 25 50
SECTION 26 27 26 - WIRING DEVICES

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. This section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to wiring devices specified herein.

1.2 DESCRIPTION OF WORK

A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry, but not utilize electrical energy.

B. Types of electrical wiring devices in this Section include the following:
   1. Receptacles
   2. Switches
   3. Wall Plates
   4. Floor Outlets

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of wiring devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Installer: Qualified with at least 2 years of successful installation experience on projects with electrical installation work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring devices.

B. UL Compliance and Labeling: Provide electrical wiring devices which have been UL listed and labeled.

C. NEMA Compliance: Comply with NEMA standards for general and specific purpose wiring devices.
D. NECA Compliance: Comply with NECA’s “Standard of Installation."

1.5 SUBMITTALS

A. Product Data: Submit manufacturer’s data on electrical wiring devices.

2. PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products of one of the following:

1. Pass and Seymour Corporation
2. Cooper
3. Hubbell, Inc.
4. Leviton, Inc.
5. Crouse Hinds
6. Lutron
7. Walker Duct

2.2 WIRING DEVICES

A. General: Where shown on the drawings, furnish and install wiring devices indicated by the appropriate symbols. Wiring devices shall be products of Pass and Seymour Corporation, or equal. Catalog numbers shown below are P & S hard use specification grade. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable.

B. Switches: Branch circuit switches shall be flush tumbler type as follows:

1. Single Pole CSB20AC1 Series - Gray
2. Two Pole CSB20AC2 Series - Gray
3. Three-Way CSB20AC3 Series - Gray
4. Four-Way CSB20AC4 Series - Gray
5. Single Pole SW With Pilot CSB20-AC1-RPL Series
6. LED and Fluorescent Dimmer Switches: Provide dimmer switches capable of 0-10 Volt dimming of LED and fluorescent loads, Lutron NTF-10-277-Gray or engineer approved equal. Provide adequate number of conductors between dimmer switches and dimmed fixtures regardless of circuiting shown on drawings.
7. Switches fed by a generator circuit shall be the same as above but RED in color.

C. Time Switches


2.3 RECEPTACLES
A. All receptacles shall be side and back wired, self-grounding of the type indicated on the drawings, or as follows. Catalog numbers shown below are Pass & Seymour specification grade unless otherwise indicated. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable:

1. Duplex Convenience Receptacles CRB5362 Series-Gray
   20A-125V (Grounding Type)

2. Weatherproof Duplex Receptacles CRB5362-Gray-WP Series-
   20A-125V (Grounding Type) Weatherproof Plate

3. Duplex GFI Receptacle 2095 Series-Gray
   20A-125V

4. Weatherproof Duplex GFI Receptacle 20A-125 Volt
   2095 Series-Gray with WP Wall Plate

5. Duplex USB Receptacle TR5362USB-Gray

6. Clock Hanger Outlet S3733-SS

7. Hospital Grade Receptacle PS8300H Gray for Normal Power and
   20A-125 Volt
   PS8300H Red for Emergency Power

8. Hospital Grade GFI Receptacle 20A-125 Volt
   2095HG Gray for Normal Power and
   2095HG Red for Emergency Power

9. Tamper Resistance Receptacle TR63-Gray for Normal and
   TR63-Red for Emergency

10. Isolated Ground Receptacles IG5362 with Orange Cover Plate
    20A-125 Volt, Ground Wire shall be routed back to main switchboard ground
    or separately derived system ground in accordance with NEC requirements.

2.4 PLATES

A. Furnish and install wall plates for all wiring devices. Where switches and/or receptacles are shown adjacent to each other, provide a common cover plate for each group of devices. Oversize plates are not acceptable.

1. Plates shall be Pass and Seymour Type 302 stainless steel.

2. Cover plates for all electrical devices shall be engraved with panel and circuit no. designation. Engraving shall be 1/8” high, block style letters, with black filler on front side of cover plates.
3. Weatherproof switch plates shall be Crouse Hinds DS185 type.
4. Weatherproof receptacle plates shall be Crouse Hinds WLRD1 type.
5. "In-Use" Weatherproof plates shall be Intermatic WP5000 Series. Provide necessary number of gangs, mounting bases, inserts and gaskets.

2.5 TWO PIECE SURFACE METAL RACEWAYS

A. Where indicated on the drawings, provide Wiremold (or equivalent) Series ALA4800 two-piece, aluminum, surface metal raceway systems complete with all necessary electrical and telecommunications devices, bases, covers, dividers, wire clips, couples, inserts, end fittings, device mounting brackets, device covers, etc. to ensure a complete and functional installation.

B. Cover plates for all power devices installed in two piece surface metal raceways shall be engraved with panel and circuit no. designation. Engraving shall be 1/8" high, block style letters, with black filler.

2.6 FLOOR OUTLETS

A. Flush Mounted Floor Boxes and Floor Outlets. See plans for types. Unless noted otherwise on the plans provide one receptacle faceplate, and one blank faceplate (to support telecom devices) for each flush mounted floor convenience outlet. When carpet is indicated on the finish schedule, supply each floor box or outlet with an appropriate carpet flange.

B. Poke-Thru Service Fittings and Service Pedestals: See plans for types. Provide all necessary faceplate types, conduit adapters for installation on counter tops and all other accessories as noted on the drawings, or as required to meet specified project needs.

2.7 Where devices are installed on exposed fittings or boxes, the plates shall be galvanized and of a type designed to fit the box. Blank covers shall be installed on all boxes without devices or fixtures, of same type as installed on devices in the room or area.

2.8 Test wiring devices to ensure electrical continuity of grounding connections and proper polarity.

3. EXECUTION

3.1 INSTALLATION

A. Install wiring devices as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other work including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices and other work.

C. Testing: Test wiring devices for electrical continuity of grounding connections and proper polarity. Test wiring devices to demonstrate compliance with requirements.
D. Where devices are installed on exposed fittings or boxes, the plates shall be galvanized and of a type designed to fit the box. Blank covers shall be installed on all boxes without devices or fixtures, of same type as installed on devices in the room or area.

E. All outlets shall be located as shown on the drawings, except that where practicable, outlets shall be located in center of panels or trim or otherwise symmetrically located to conform with existing structural layout. Outlets incorrectly installed shall be corrected. Damaged items or damaged finishes shall be repaired or replaced at no expense to the Owner.

F. Outlets shall be set plumb or horizontal and shall extend to the finished surface of the walls, ceiling or floor, as the case may be, without projecting beyond the same.

G. Receptacles, switches, etc., shown on wood trim, cases or other fixtures shall be installed symmetrically; and, where necessary, shall be set with the long dimensions of the plate horizontal, or ganged in tandem.

H. Where dimmer switches are shown adjacent to standard switches, both shall be installed in separate back boxes with adequate space between so that neither cover plate requires cutting.

I. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.

J. Where devices are shown mounted adjacent to one another on the drawings, provide multi-gang faceplates to cover all devices.

END OF SECTION 26 27 26
SECTION 26 29 13 - MOTOR CONTROLLERS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to the work of this Section.

B. Division 26 "Basic Electrical Materials and Methods" section apply to the work specified in this Section.

C. Control Devices: Division 23 control devices such as aquastats, electric-pneumatic and pneumatic-electric switches, thermostats, freezestats, etc. are furnished and connected by the Division 23 Contractor unless specifically noted otherwise.

D. Motors: All motors shown on the drawings shall be furnished and set in place under the specific section in which the motor is specified.

E. Motor starters specified in other sections of this specification such as Division 23 shall be provided with power wiring by the Division 26 Contractor.

1.2 DESCRIPTION OF WORK

A. Extent of motor starter work is indicated by drawings and schedules.

B. Type of motor starters specified in this Section are as follows:

   1. Full Voltage Non-Reversing Magnetic Starters
   2. Reduced Voltage Starters
   4. Remote Controls

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of motor starters of types, ratings and characteristics required, whose products have been in satisfactory operation in similar service for not less than five (5) years.

B. Firm with at least three (3) years of successful installation experience on projects utilizing motor starters similar to that required for this project.
1.4 REFERENCES

A. NEC Compliance: Comply with NEC requirements as applicable to wiring methods, construction, and installation of motor starters.

B. NFPA Compliance: Comply with applicable requirements of NFPA standard 70E "Standard for Electrical Safety Requirements for Employee Workplaces."

C. UL Compliance: Comply with applicable requirements of UL 486A "Wire, Connectors, and Soldering Lugs for Use with Copper Connectors," and UL 508 "Electrical Industrial Control Equipment" pertaining to the installation of motor starters. Provide motor starters and components which are UL listed and labeled.


1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data on motor starters.

B. Provide shop drawings of equipment being provided and control diagrams for each motor starter.

2. PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the requirements, provide motor starters of one of the following:

1. Allen Bradley Co.
2. General Electric Co.
3. Siemens
4. Square D Co.
A. Except as otherwise indicated, provided motor starters and ancillary components which comply with the manufacturer's standard materials, and which are designed and constructed in accordance with published product information as required for a complete installation. Unless specifically indicated otherwise provide all power wiring, disconnects, starters, relays, hand-off-auto switches, pilot lights, motor connections, supports and all miscellaneous and necessary appurtenances required for a satisfactory and complete working system.

2.3 FULL VOLTAGE NON-REVERSING MAGNETIC STARTERS

A. Provide magnetic starters for three phase motors. Motor starters shall be full voltage non-reversing across the line magnetic type rated in accordance with NEMA standard sizes and horsepower ratings. Magnetic starters shall not be less than NEMA size one.

1. Each starter shall have a removable hinged cover capable of being padlocked. Enclosures shall be NEMA 1 general purpose type unless indicated otherwise. Provide watertight and dust tight enclosures for units installed outside, or as indicated on the drawings. Starters shall be provided with double break silver alloy contacts. All contacts shall be replaceable without removing wiring or the starter from the enclosure.

B. Magnetic starters shall be provided with the following additional equipment:

1. Overload relays shall be an integral part of the motor starter. Overload relays shall have a minimum ±10 percent adjustment from the nominal heater rating. Heaters shall be available such that when used with the ±10 percent adjustment, a continuous selection of motor full load currents can be obtained through the size limitations of the starter. Overload relays shall be manual reset and field convertible from manual to automatic reset. Overload relays shall be melting alloy or bimetallic type. Thermal units shall be of one piece construction and interchangeable. The starter unit shall be inoperative if the thermal unit is removed. Provide 3 overload relays, one for each phase of the three phase starter.

2. Starters shall be suitable for the addition of at least three normally open and three normally closed auxiliary contacts. Provide a minimum of two normally open and two normally closed contacts unless additional contacts are scheduled on the drawings or required for proper control of the equipment.

3. In each magnetic starter provide cover mounted hand-off-auto selector switch complete with a manual overload reset button and a red "On" pilot light. Provide a control transformer with a secondary voltage of 120V, complete with primary overload and short circuit protection.

4. Time delay relays with time delay after energization shall be provided for starters indicated, or as required for proper control of equipment. Time delay feature shall be adjustable from 0 to 60 seconds and set as indicated on the drawings.

2.4 PART WINDING REDUCED VOLTAGE MAGNETIC STARTERS

B. Provide starters with the equipment listed in paragraph 2.3, B above.

C. Provide additional equipment for combination starters in accordance with paragraph 2.3, B above.

2.5 WYE-DELTA REDUCED VOLTAGE MAGNETIC STARTERS

A. Provide Allen-Bradley Bulletin 737 wye-delta starters, magnetic, non-reversing, reduced-inrush, closed-circuit transition type. Limit the inrush line current to a maximum of 35 percent of the locked rotor current. Coordinate and certify compatibility with the motor and driven equipment. Provide three thermal overload relays in series with each winding. Provide starter capable of interrupting 10 times motor full load rating.

B. Provide starters with the equipment listed in paragraph 2.3, B above.

2.6 AUTO-TRANSFORMER REDUCED VOLTAGE MAGNETIC STARTERS

A. Provide Allen-Bradley Bulletin 746 auto-Transformer starters, magnetic, non-reversing, reduced-inrush, closed-circuit transition type. Provide minimum tap of 65 percent for motors 30 hp or less, and 50 percent for motors in excess of 30 hp. Limit the inrush line current to a maximum of 43 percent and 25 percent respectively, of the locked rotor current. Provide thermal overload protection in each phase. Provide starter capable of interrupting 10 times motor full load rating.

B. Provide starters with the equipment listed in paragraph 2.3, B above.

2.7 FULL VOLTAGE NON-REVERSING COMBINATION STARTERS

A. Full voltage non-reversing combination starters shall be Square D Class 8538 (or equal) unless otherwise indicated. Provide additional equipment for combination starters in accordance with the requirements outlined in paragraph 2.3.2 above. Where combination starters are shown on the drawings, a separate starter and disconnect switch may be substituted at the Contractor's option, provided adequate space is available for the installation.

B. Provide fused disconnect switches with Class R type fuse rejection clips. If breakers are shown, provide breakers with a minimum of 22,000 RMS symmetrical amps interrupting capacity.

2.8 MANUAL MOTOR STARTERS
2.9 REMOTE CONTROLS

A. Provide Square D standard duty oil-tight pushbuttons, pilot lights, and/or selector switches where indicated on the drawings, or wherever required for proper control of the equipment. Units shall be flush mounted in finished areas and surface mounted in unfinished areas.
3. **EXECUTION**

3.1 **INSTALLATION**

A. Install motor starters as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices; complying with applicable requirements of the NEC, UL and NEMA Standards, to ensure that products fulfill requirements.

B. Coordinate with other work including motor and electrical wiring/cabling work as necessary to interface installation of motor starters with other work.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std. 486A.

D. Install fuses in fusible disconnect switches as required.

E. Adjusting and Cleaning: Inspect electrical starter's operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movements.

F. Field Quality Control: Subsequent to connecting wire/cables, energize motor starter circuitry and demonstrate functioning of equipment in accordance with specified requirements. Where necessary, correct malfunctioning units and retest to demonstrate compliance. Ensure that direction of rotation of each motor fulfills requirements.

END OF SECTION 26 29 13
SECTION 26 29 23 – VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1. GENERAL

1.1 SECTION INCLUDES

A. Variable frequency controllers.

1.2 REFERENCE STANDARDS


C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.


1.3 SUBMITTALS

A. See Section 01 33 00 – Submittal Procedures.

B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

D. Test Reports: Indicate field test and inspection procedures and test results.

E. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

F. Manufacturer’s Field Reports: Indicate start-up inspection findings.
G. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and
describe operating limits that may result in hazardous or unsafe conditions.

H. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

1.4 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in
this section with minimum five years documented experience and with service facilities within
200 miles of Project.

C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose
specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or
heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer’s written instructions. Lift only with lugs provided for
the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

PART 2. PRODUCTS

2.1 MANUFACTURERS

A. Toshiba; Model Q9 or Model AS3: www.toshiba.com

B. ABB; Model ACH550: www.abb.com

C. Yaskawa; Model Z1000 www.yaskawa.com

2.2 DESCRIPTION

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads,
in conformance with requirements of NEMA ICS 7. Select unspecified features and options in
accordance with NEMA ICS 3.1.

1. Employ microprocessor-based inverter logic isolated from power circuits.
2. Employ pulse-width-modulated inverter system.
3. Include a DC link reactor for reduction of harmonic distortion.
4. The controller, and all associated components, shall be supplied by a single vendor.
5. The controller will be operating a variable volume fan motor, or water pump motor for HVAC application.
6. System voltage shall be indicated on front of ASD, using minimum of 1-inch high letters.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public. No disconnects in VFD cabinet. Disconnect must be in separate enclosure.

2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage for motors rated below 40 HP: 200 volts, three phase, 60 Hertz, with a voltage tolerance of +/- 10% and a frequency tolerance of +/- 2 Hz.

B. Rated Output: Output frequency shall vary between 0.1 Hz and 400 Hz. Frequency resolution shall be 0.01 Hz digital and 0.03 Hz analog with an accuracy of +/-0.2% of maximum frequency at 25 degrees Celsius. Maximum voltage frequency shall be adjustable from 25 Hz to 400 Hz. Voltage boost shall be adjustable from 0% to 30% with starting frequency adjustable from 0 Hz to 10 Hz. The output current shall be 100% continuous and 110% for 60 seconds, based on NEC table 430-150 (Full-Load Current, Three-Phase Alternating Current Motors) for 200 volts or 460 volts.

C. The controller shall contain three critical frequency jump points with individual bandwidth. Upper and lower frequency limits shall be capable of being varied.

D. The PWM carrier frequency shall be adjustable from 5000 Hz to 15000 Hz.

E. The drive shall contain two separate acceleration/deceleration times (0.1 to 6000 seconds) with a choice of linear, S, or C curves. The drive shall have a standard dynamic electric braking for motors rated 30 HP or below. The drive shall restart into a rotating motor by sensing the coasting motor speed and matching that frequency. The drive shall have adjustable soft stall (10%-150%) and adjustable electronic overload protection (10%-100%).

F. The drive shall have external fault input, be capable of re-setting faults remotely and locally.

G. Input Signal:
   1. 0 to 10 v DC.
   2. 0 to 5 v DC.
   3. 4 to 20 mA DC.

H. Manual bypass is not required on VFD unless indicated on bid documents.
2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current, output power (kw), and motor RPM.
PART 3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA ICS 7.1, manufacturer’s instructions, and per drawings.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Provide engraved plastic nameplates; refer to Section 26 05 53 for product requirements and location.

D. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

E. When remote service disconnect is required, provide with auxiliary contacts hardwired to VFD safety circuit to shut down VFD, if disconnect is opened.

3.2 FIELD QUALITY CONTROL

A. Prior to initial energization, provide the service of the manufacturer’s field representative to prepare and start controllers.

3.3 MAINTENANCE

A. Furnish two extra of each air filter.

B. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

END OF SECTION 26 29 23
SECTON 26 32 13 – ELECTRICAL EMERGENCY STANDBY POWER SYSTEM GENERATOR SET

1. GENERAL

1.1 SCOPE

A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.

B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.

C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.2 CODES AND STANDARDS

A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.

   1. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
   2. NFPA37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
   4. NFPA99 – Essential Electrical Systems for Health Care Facilities
   5. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

B. The generator set and supplied accessories shall meet the requirements of the following standards:

   1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
   2. UL142 – Sub-base Tanks
   3. UL1236 – Battery Chargers
   4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.
C. The control system for the generator set shall comply with the following requirements.

2. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
3. FCC Part 15, Subpart B.
4. IEC8528 part 4. Control Systems for Generator Sets
5. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
6. UL508. The entire control system of the generator set shall be UL508 listed and labeled.
7. UL1236 – Battery Chargers.

D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 ACCEPTABLE MANUFACTURERS

A. Generator Manufacturers:

Only approved bidders shall supply equipment provided under this contract. Equipment specifications for this project are based on generator sets manufactured by Cummins Power Generation with microprocessor-based controls. Equivalent systems and equipment provided by Kohler, Caterpillar, or Generac are acceptable. Equipment by other suppliers that meets the requirement of this specification is acceptable, if approved not less than 2 weeks before scheduled bid date. Proposals must include a line by line compliance statement based on this specification.

B. Automatic Transfer Switch Manufacturers:

1. Russ Electric shall be the only approved automatic transfer switch manufacturer. Generator manufacturer shall fully coordinate operation and communication of generator and automatic transfer switch signals to ensure compatibility between Russ Electric transfer switches and the generator for a fully functional system.

2. PRODUCTS

2.1 GENERATOR SET

A. Ratings

1. The generator set shall operate at 1800 rpm and at a voltage of: 480 Volts AC, Three phase, 4-wire, 60 hertz.
2. The generator set shall be rated at 750 kW, 937.5 kVA at 0.8 PF, Standby rating, based on site conditions of: Altitude 758 ft. ambient temperatures up to 104 degrees F.
3. The generator set rating shall be based on emergency standby service.

B. Performance

1. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.

2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.

3. The diesel engine-generator set shall accept a single step load of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.

4. Motor starting capability shall be a minimum of 2944 kVA. The generator set shall be capable of recovering to a minimum of 90% of rated no load voltage following the application of the specified kVA load at near zero power factor applied to the generator set. Maximum voltage dip on application of this load, considering both alternator performance and engine speed changes shall not exceed 15%.

5. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.

6. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.

C. Construction

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.

2. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. All active control components shall be installed within a UL/NEMA 3R enclosure. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

D. Connections

1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.

2. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
3. Generator set control interfaces to other system components shall be made on a permanently labeled terminal block assembly. Labels describing connection point functions shall be provided.

4. Generator set shall be provided with a connection point dedicated for quick connection to a portable load bank. Connection shall be sized for testing generator at 100% of rated capacity. Provide number of lugs based on parallel sets of #500 KCMIL cable connections to portable load bank.

2.2 ENGINE AND ENGINE EQUIPMENT

A. The engine shall be diesel, 4 cycle, radiator and fan cooled. Minimum displacement shall be 1860 cubic inches, with 12 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:

1. An electronic governor system shall provide automatic isochronous frequency regulation. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed. The governing system shall include a programmable warm up at idle and cooldown at idle function. While operating in idle state, the control system shall disable the alternator excitation system.

2. Skid-mounted radiator and cooling system rated for full load operation in 122 degrees F (50 degrees C) ambient as measured at the alternator air inlet. Radiator fan shall be suitable for use in a system with 0.5 in H2O restriction. Radiator shall be sized based on a core temperature that is 20°F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture prior to shipping. Rotating parts shall be guarded against accidental contact.

3. Electric starter capable of three complete cranking cycles without overheat.

4. Positive displacement, mechanical, full pressure, lubricating oil pump.

5. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.

6. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element. Fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.

7. Replaceable dry element air cleaner with restriction indicator.

8. Flexible supply and return fuel lines.

9. Engine mounted battery charging alternator, 35-ampere minimum, and solid-state voltage regulator.

10. Coolant heater
a. Engine mounted, thermostatically controlled, coolant heater. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.

b. The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall provisions to isolate the heater for replacement of the heater element without draining the coolant from the generator set. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.

c. The coolant heater shall be provided with a DC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system. Provide a circuit for the coolant heater sized in accordance with NEC requirements (circuit breaker, wire and conduit), and fed from the nearest standby emergency panelboard. Route circuit from panelboard to heater underground, buried a minimum of 42” below finished grade.

d. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104F (40C) in a 40F (4C) ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.

11. Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.

12. Starting and Control Batteries shall be calcium/lead antimony type, 24 volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors. The batteries shall be capable of a minimum of three complete 15-second cranking cycles at 40F ambient temperature when fully charged.

13. A UL listed/CSA certified 10 amp voltage regulated battery charger shall be provided for each engine-generator set. The charger may be located in an automatic transfer switch, or may be wall mounted, at the discretion of the installer. Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:

   a. Loss of AC power - red light
   b. Low battery voltage - red light
   c. High battery voltage - red light
   d. Power ON - green light (no relay contact)

2.3 AC GENERATOR

   A. Charger shall include an Analog DC voltmeter and ammeter, 12 hour equalize charge timer, and AC and DC fuses.
B. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system and shall be UL1446 listed. Actual temperature rise measured by resistance method at full load shall not exceed 125 degrees Centigrade.

C. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

D. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

E. The sub-transient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.

2.4 GENERATOR SET CONTROL

A. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

B. The control shall be mounted on the generator set, or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

C. The generator set mounted control shall include the following features and functions:

   1. Control Switches

      a. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

      b. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

      c. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
2. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:

a. Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.

b. Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be color coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output. Only digital metering shall be required.

c. The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.

d. The control system shall log total number of operating hours, total kWh, and total control on hours, as well as total values since reset.

3. Generator Set Alarm and Status Display.

a. The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:

1) The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).

2) The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.

3) The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.

4) The control shall include an amber common warning indication lamp.
b. The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:

1) low oil pressure (warning)
2) low oil pressure (shutdown)
3) oil pressure sender failure (warning)
4) low coolant temperature (warning)
5) high coolant temperature (warning)
6) high coolant temperature (shutdown)
7) high oil temperature (warning)
8) engine temperature sender failure (warning)
9) low coolant level (warning)
10) fail to crank (shutdown)
11) fail to start/overcrank (shutdown)
12) overspeed (shutdown)
13) low DC voltage (warning)
14) high DC voltage (warning)
15) weak battery (warning)
16) low fuel-daytank (warning)
17) high AC voltage (shutdown)
18) low AC voltage (shutdown)
19) under frequency (shutdown)
20) over current (warning)
21) over current (shutdown)
22) short circuit (shutdown)
23) over load (warning)
24) emergency stop (shutdown)
25) (4) configurable conditions

c. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

D. Engine Status Monitoring

1. The following information shall be available from a digital status panel on the generator set control:

a. engine oil pressure (psi or kPA)

b. engine coolant temperature (degrees F or C)

c. engine oil temperature (degrees F or C)
d. engine speed (rpm)
e. number of hours of operation (hours)
f. number of start attempts
g. battery voltage (DC volts)

2. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

E. Engine Control Functions

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
4. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
5. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

F. Alternator Control Functions:

1. The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
2. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.

3. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.

4. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

5. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

G. Other Control Functions

1. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

H. Control Interfaces for Remote Monitoring:

1. The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.

2. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

3. A fused 10 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

2.5 OTHER EQUIPMENT TO BE PROVIDED WITH THE GENERATOR SET
A. Provide and install a 20-light LED type remote alarm annunciator with horn, located in the dock/receiving room. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems for the local generator control panel. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2. The interconnecting wiring between the annunciator and other system components shall be monitored and failure of the interconnection between components shall be displayed on the annunciator panel.

B. The annunciator shall include the following alarm labels, audible annunciation features, and lamp colors:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lamp Color</th>
<th>Audible Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Power (to Loads)</td>
<td>Green</td>
<td>No</td>
</tr>
<tr>
<td>Genset Supplying Load</td>
<td>Amber</td>
<td>No</td>
</tr>
<tr>
<td>Genset Running</td>
<td>Green</td>
<td>No</td>
</tr>
<tr>
<td>Not in Auto</td>
<td>Red (Flashing)</td>
<td>Yes</td>
</tr>
<tr>
<td>High Battery Voltage</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Low Battery Voltage</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Charger AC Failure</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Fail to Start</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Low Engine Temperature</td>
<td>Amber</td>
<td>Yes</td>
</tr>
<tr>
<td>Pre-High Engine Temperature</td>
<td>Amber</td>
<td>Yes</td>
</tr>
<tr>
<td>High Engine Temperature</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Pre-Low Oil Pressure</td>
<td>Amber</td>
<td>Yes</td>
</tr>
<tr>
<td>Low Oil Pressure</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Overspeed</td>
<td>Red</td>
<td>Yes</td>
</tr>
<tr>
<td>Low Coolant Level</td>
<td>Amber</td>
<td>Yes</td>
</tr>
<tr>
<td>Low Fuel Level</td>
<td>Amber</td>
<td>Yes</td>
</tr>
<tr>
<td>Network OK</td>
<td>Green</td>
<td>Yes</td>
</tr>
<tr>
<td>(4) Spares</td>
<td>Configurable</td>
<td>Configurable</td>
</tr>
</tbody>
</table>

Low battery voltage lamp shall also be lighted for low cranking voltage or weak battery alarm.

C. The generator set shall be provided with a unit mounted main line circuit breaker(s), sized to carry the rated output current of the generator set. The circuit breakers shall incorporate electronic trip that operates to protect the alternator under all overcurrent conditions and selectively coordinates with emergency electrical distribution system. If circuit breaker is shared by non-emergency branches along with emergency branches, then the next downstream circuit breaker of the non-emergency system shall also coordinate per NEC. The supplier shall submit
time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

D. Outdoor Weather-Protective Enclosure

1. The generator set shall be provided with an outdoor enclosure, with the entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

2. The enclosure shall provide sound attenuation so generator set has a maximum of 79dB at 20 ft. from the enclosure at rated output.

3. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturers standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
   a. Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.
   b. Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
   c. Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
   d. Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
   e. Salt Spray, per ASTM B117-90, 1000+ hours.
   f. Humidity, per ASTM D2247-92, 1000+ hours.
   g. Water Soak, per ASTM D2247-92, 1000+ hours.

4. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.

5. Enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All hardware and hinges shall be stainless steel.

6. The enclosure shall include the following maintenance provisions:
   a. Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
   b. External radiator fill provision.
E. Provide a sub-base fuel tank for the generator set, sized to allow for full load operation of the generator set for **24 hours**. The sub-base fuel tank shall be UL142 listed and labeled. Installation shall be in compliance to NFPA37. The fuel tank shall be a double-walled, steel construction and include the following features:

1. Emergency tank and basin vents.
2. Mechanical level gauge.
3. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by the engine manufacturer and in compliance to UL2200 and NFPA 37 requirements.
4. Leak detection provisions, wired to the generator set control for local and remote alarm indication.
5. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
7. Integral lifting provisions.

F. Performance Testing

1. Performance test shall be a 100% load test to include resistive and reactive load to nameplate rating at 80% power factor using resistive and reactive load banks. Engine generator set shall be operated at 75% of rated load for at least 2 hours and then 100% rated load for at least 4 hours. In addition, a full load acceptance test of 100% of rated load shall be applied to generator with voltage and frequency stabilization occurring per specifications.

2.6 AUTOMATIC TRANSFER SWITCHES - ISOLATION/BYPASS TYPE

A. General

1. Furnish and install automatic transfer and bypass-isolation switches with number of poles, amperage, voltage and withstand ratings as shown on the plans. Each system shall be the product of one manufacturer and consist of two elements: an automatic transfer switch and a two-way bypass-isolation switch.
2. Transfer switches shall be for 3 phase, 4-wire service with switched neutrals.

B. Mechanically-held transfer switch:

1. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized to minimize power consumption and heat generation. The switch shall be positively locked and unaffected by voltage variations or momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or emergency.
2. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts. ATS' utilizing components of molded-case circuit breakers, contactors or parts thereof which have not been intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

3. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

C. Bypass-Isolation Switch

1. A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven. Arrangements utilizing electrically-driven contacts are prohibited.

2. Power interconnections shall be silver-plated copper bus bar. The only field-installed power connections shall be at the service and load terminals of the bypass-isolation switch. All control interwiring shall be provided with disconnect plugs.

3. Separate bypass and isolation handles shall be utilized to provide clear distinction between the two functions. The bypass handle shall provide three operating modes: “Bypass to Normal”, “Automatic” and “Bypass to Emergency.” Bypass to the load-carrying source shall be effected without any interruption of power to the load ( make-before-break contacts ). Load break-type bypass for ATS test and isolation shall not be acceptable. The operating speed of the bypass contacts shall be the same as that of the associated automatic transfer switch and shall be independent of the speed at which the manual bypass handle is operated. In the “Automatic” mode, bypass contacts shall be all open so they will not be subjected to fault currents.

4. The isolation handle shall provide three operating modes: “Closed”, “Test”, and “Open.” The “Test” mode shall permit testing of the entire emergency power system, including the automatic transfer switches, without any interruption of power to the load. The “Open” mode shall completely isolate the automatic transfer switch from all source and load power conductors. When in the “Open” mode, it shall be possible to completely withdraw the automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or the use of any tools.

5. When the isolation switch is in the “Test” or “Open” mode, the bypass switch shall function as a manual transfer switch allowing transfer and retransfer of the load between the two available sources without the feedback of load-regenerated voltage to the transfer switch. This transfer/retransfer operation shall comply with Paragraph 42.7 of UL 1008.

D. Microprocessor Control Module
1. The control module shall direct the operation of the transfer switch. The module’s sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent digital communications capability. The control module shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the control module to be disconnected from the transfer switch for routine maintenance.

2. The control module shall be completely enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on plug-in printed circuit boards for maximum reliability. Interfacing relays shall be industrial control grade plug-in type with dust covers. All relays shall be identical to minimize the number of unique parts.

3. The control panel shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 (ANSI C37.90a-1974) and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

E. Engine Generator Exerciser Timer:

1. An engine generator-exercising timer shall be built in to the ATS control module and shall include a selector switch to select exercise with or without load transfer. The exerciser shall be solid-state for maximum reliability and minimum maintenance and shall be programmable to enable exercise for 1 minute to 24 hours per day for 0 to 7 days per week. Exercise settings shall be set by pushbutton and a digital display shall be provided to indicate settings. A replaceable, built-in battery shall be provided to enable the exerciser to continue to operate for up to two weeks without external power. A built-in battery charger shall extend battery life to at least five years. Loss of the battery shall not disable the exercise function as long as normal power is present.

F. Inphase Monitor:

1. An inphase monitor shall be built in to the ATS and shall control transfer so that motor load inrush currents do not exceed normal starting currents, to avoid nuisance tripping of circuit breakers and possible mechanical damage to motor couplings.

2. The inphase monitor shall operate without external control of electrical loads and without any external control of the power sources.

3. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and permit transfer the first time the sources are within 15 electrical degrees and only if transfer can be accomplished within 60 electrical degrees as determined by monitoring the frequency difference. Inphase transfer shall be accomplished if both sources are within 2 Hertz of nominal frequency and 70% or more of nominal voltage.

G. Operation:

1. Three-phase control shall be provided for three-phase power sources. Three-phase controls shall include a selector switch to enable temporary operation on single-phase power sources.
2. The voltage of each phase of the normal source shall be monitored, with pickup adjustable from 85 to 100% and dropout adjustable from 75 to 98% of pickup setting, both in increments of 1%, and shall be fully field-adjustable without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pick up at 90% and dropout at 85%.

3. Single-phase voltage sensing of the emergency source shall be provided, with a pickup adjustable from 85 to 100% (and dropout fixed at 84 to 86% of pickup), and frequency sensing with pickup adjustable from 90 to 100% (and dropout fixed at 87 to 89% of pickup).

4. Both pickup settings shall be fully field-adjustable in 1% increments without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pick up at 90% voltage and 95% frequency.

5. The control module shall include four time delays that are fully field-adjustable in increments of at least 13 steps over the entire range as follows:
   a. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. Adjustable from 0 to 6 seconds. Factory set at 1 second.
   b. Transfer to emergency time delay. Adjustable from 0 to 5 minutes. Factory set at 0 minutes.
   c. Retransfer to normal time delay. Time delay is automatically bypassed if emergency source fails and normal source is acceptable. Adjustable from 0 to 30 minutes. Factory set at 30 minutes.
   d. Unloaded running time delay for emergency engine generator cooldown. Adjustable from 0 to 60 minutes. Factory set at 5 minutes.

6. A set of DPDT gold-flashed contacts rated 10 amps, 32VDC shall be provided for a low-voltage engine start signal when the normal source fails. The start signal shall prevent dry cranking of the generator by requiring the generator to reach proper output, and to run for the duration of the cooldown setting, regardless of whether the normal source restores before the generator is ready to accept the load.

H. A momentary-type test switch shall be provided to simulate a normal source failure. Also, terminals for a remote contact which opens to signal the ATS to transfer to emergency and terminals for remote contacts which open to inhibit transfer to emergency and/or re-transfer to normal shall be provided.

I. A visual position indicator shall be provided to indicate bypass-isolation switch position. Pilot lights shall indicate availability of power sources and automatic transfer switch position. A prominent and detailed instruction plate shall be furnished.

J. One set of auxiliary contacts shall be provided rated 10 amps, 480 VAC, consisting of one contact closed when the ATS is connected to normal and one contact closed when the ATS is connected to emergency.
K. Output terminals to signal the actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source, shall be provided.

L. Compliance with Codes and Standards:

1. The ATS shall conform to the requirements of:
   a. UL 1008 - Standard for Automatic Transfer Switches
   b. NFPA 70 - National Electrical Code, including use in emergency and standby systems in accordance with Articles 517, 700, 701, and 702.
   c. NFPA 99 - Essential Electrical Systems for Health Care Facilities
   d. NFPA 110 - Standard for Emergency and Standby Power Systems
   e. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems (Orange Book)
   g. NEMA Standard ICS2-447 - AC Automatic Transfer Switches
   h. IEC - Standard for Automatic Transfer Switches

2. The ATS shall be UL listed in accordance with UL 1008. Requirements of UL 1008 include but are not limited to as follows:
   1. Rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads as referred to in Paragraph 38.13 of UL 1008.
   2. Switches rated 400 amperes and below shall be suitable for 100% tungsten-filament lamp load. Switches rated above 400 amperes shall be suitable for 30% tungsten-filament load.
   3. Overload and endurance at 480 volts AC per Tables 25.1, 25.2, 27.1, and 27.2 of UL 1008 when enclosed according to Paragraph 1.6.
   4. Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits.
   5. No welding of contacts. Transfer switch must be electrically operable to alternate source after the withstand current tests.
   6. Dielectric tests at 1960 volts, rms, minimum after the withstand current test.

M. Withstand Current Ratings:

1. The ATS shall be rated to withstand 65,000 amps rms symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans.

N. Tests and Certification

1. All production units shall be subjected to the following factory tests:
a. The complete ATS shall be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements.

b. The switch shall be subjected to a dielectric strength test per NEMA Standard ICS1-109.21.

O. Configuration and Manufacturer:

1. The ATS shall be furnished in a NEMA Type 1 enclosure unless otherwise shown on the plans.
2. The Isolation/Bypass type ATS shall be an ASCO model 7000 or approved equivalent. Equivalent equipment by Cummins is acceptable.

3. OPERATION

3.1 SEQUENCE OF OPERATION

A. Generator set shall start on receipt of a start signal from automatic transfer switches. The start signal shall be via hardwired connection to the generator set control.

B. The generator set shall complete a time delay start period as programmed into the control.

C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:

D. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.

E. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.

F. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.

G. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous state.

H. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
I. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.

J. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

4. OTHER REQUIREMENTS

4.1 SUBMITTALS

A. Within 10 days after award of contract, provide six sets of the following information for review:

1. Manufacturer’s product literature and performance data, sufficient to verify compliance to specification requirements.
2. A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
3. Manufacturer’s certification of prototype testing.
4. Manufacturer’s published warranty documents.
5. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
6. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
7. Manufacturer’s installation instructions.

4.2 FACTORY TESTING

A. The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.

B. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.

C. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

4.3 INSTALLATION

A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer’s instructions and instructions included in the listing or labeling of UL listed products.
B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.

C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer’s instructions and seismic requirements of the site.

D. Equipment shall be initially started and operated by representatives of the manufacturer.

E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.

4.4 ON-SITE ACCEPTANCE TEST

A. The complete installation shall be tested for compliance with the specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.

B. Installation acceptance tests to be conducted on-site shall include a "cold start" test, a two hour full load test, and a one step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank and make temporary connections for full load test, if necessary.

C. Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

D. Additionally, perform a power failure test on the entire installed system confirming that the generator system operates at generator’s full rated load for a duration not less than the generator’s rated number of hours. Coordinate exact requirements with Owner’s personnel.

4.5 TRAINING

A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.

4.6 SERVICE AND SUPPORT

A. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.

C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

4.7 WARRANTY

A. The generator set and associated equipment shall be warranted for a period of not less than 5 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

END OF SECTION 26 32 13
SECTION 26 41 00 – LIGHTNING PROTECTION SYSTEM

PART 1. GENERAL

1.1 SUMMARY

A. Provide a complete lightning protection system for the building(s) or structures shown on the contract drawings. The design of this system is to be in strict accordance with this section of the specifications and all contract drawings that apply.

B. The lightning protection system shall be designed and installed by a firm actively engaged in the installation of Underwriters Laboratories Inc. (UL) Master Labeled Lightning Protection Systems and shall be so listed by Underwriters Laboratories Inc. The completed system shall comply with the latest editions of Underwriters Laboratories Inc. "Installation Requirements for Lightning Protection Systems, UL96A" and of the National Fire Protection Association's "NFPA® 780, Standard for the Installation of Lightning Protection Systems". The system shall be physically inspected by UL and the Master Label® Certificate of Inspection shall be provided to the building owner and made available for viewing on the UL website, https://lps.ul.com.

C. The work covered under this section of the specification consists of furnishing labor, materials and services required for the completion of a functional and unobtrusive lightning protection system approved by the architect, engineer and Underwriters Laboratories Inc.

D. System designs shall be completely integrated with the architectural design of the facility, and shall be reviewed by the Architect/Engineer prior to installation. The lightning protection system installation in shall be fully coordinated with all other trades.

1.2 STANDARDS

A. The completed lightning protection system shall comply with the latest issue of the following standards which form a part of this specification. Where conflict occur between the two standards, the requirements of NFPA®780 shall apply.

1. NFPA® 780, Standard for the Installation of Lightning Protection Systems.
2. UL 96A, Installation Requirements for Lightning Protection Systems.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s descriptive and technical literature and catalog cuts.
B. Shop Drawings: Submit installation shop drawings shall be submitted to the Architect and Engineer for coordination with other trades and approval prior to start of the installation. Shop drawings are to show the extent of the system layout designed specifically for the building(s) or structures included in the contract drawings along with installation details of the products to be used in the installation.

1.4 QUALITY ASSURANCE

A. The installing contractor shall apply for inspection of the completed system by UL field representatives. The system is to be inspected by Underwriters Laboratories Inc, or other ANSI certified testing agency for compliance with NFPA® 780. The system shall be without deviation and the UL field representative will issue a UL Master Label® Certificate of Inspection for Lightning Protection Systems or Letter of Findings at completion of the installation, as indicated in section 3.04 below.

B. Manufacturer: Company specializing in lightning protection equipment with a minimum of five years of documented experience.

C. System Designer: Company specializing in the design of lightning protection systems with a minimum of five years of documented experience.

D. Installer: Authorized installer of system manufacturer with a minimum of five years of documented experience.

PART 2. PRODUCTS

2.1 MATERIALS

A. All materials used in the installation shall be new and shall comply in weight, size and composition as required by UL 96A and NFPA® 780 and shall be labeled or listed by Underwriters Laboratories Inc. for use in lightning protection systems. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment. The manufacturer shall be listed by UL as a manufacturer of lightning protection components.

2.2 ACCEPTABLE MANUFACTURERS

A. Harger Lightning & Grounding.

B. National Lightning Protection Corporation.

C. Robbins Lightning Protection Company.
2.3 MATERIAL REQUIREMENTS

A. Class I materials shall be used on structures or portions of structures that do not exceed 75 feet in height above grade level. Class II materials shall be used on structures that exceed 75 feet in height above grade.

B. Copper materials shall not be mounted on aluminum, Galvalume®, galvanized steel or zinc surfaces. This includes those materials that have been painted.

C. Aluminum materials shall not come into contact with earth or where rapid deterioration is possible. Aluminum materials shall not come into contact with copper surfaces or where exposed to runoff from copper surfaces. Aluminum materials shall not be attached to surfaces covered with alkaline-based paint, embedded in concrete or masonry, or installed in a location subject to excessive moisture.

2.4 AIR TERMINALS

A. Air terminals shall extend a minimum of ten inches above the object or area they are to protect. Air terminals shall be located at intervals not exceeding 20'-0" along ridges of pitched roofs and along the perimeter of flat or gently sloping roofs (flat or gently sloping roofs include roofs that have a pitch less than 3:12). Flat or gently sloping roofs exceeding 50'-0" in width shall be provided with additional air terminals located at intervals not exceeding 50'. Air terminals shall be located within two feet of the ends of the ridges, roof edges and outside corners of protected areas.

B. Air terminals shall be installed on stacks, flues, mechanical units and other objects not located within a zone of protection. Permanent metal objects on the structure having an exposed metal thickness 3/16" or greater may be substituted for air terminals and shall connected to the lightning protection system as required by the specified standards using main size conductor and bonding plates having a minimum of 3 square inches of surface contact area.

C. Air terminal bases shall be securely fastened to the structure in accordance with the specified standards. Fasteners may include stainless steel screws, bolts, nails, anchors or adhesive. Adhesive shall be compatible with the surface on which it is used. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing contractor.

D. Main conductors shall be sized as Class I or Class II materials in accordance with the specified standards. Conductors shall provide a two way, horizontal or downward path from each strike or air terminal to connections to the lightning protection ground electrode system. Conductors shall
be free of excessive splices and no bend of a conductor shall form an included angle of less than 90 degrees nor have a radius of bend less than 8 inches.

E. Conductors shall be securely fastened to the structure on which they are placed at intervals not exceeding 3 feet. Fasteners shall be of the same material or of a material equally resistant to corrosion as that of the conductor. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing contractor.

F. Connector fittings shall be listed for the purpose and of the same material as the conductor or of electrolytically compatible materials.

G. Down conductors shall be sized as Class I or Class II materials in accordance with the specified standards. Class II conductors from a higher portion of a structure shall continue to connections to the lightning protection ground electrode system. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure. In no case shall a structure have fewer than two down conductors. Down conductors shall be concealed from view. All conductors shall be concealed from view at street level.

H. In case of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals not exceeding 100 feet along the perimeter of the structure.

2.5 ROOF PENETRATIONS

A. Roof penetrations required for down conductors or for connection to structural steel framework shall be made using thru-roof assemblies with solid riser bars or conduits and appropriate roof flashing. Conductors shall not pass directly through the roof. The roofing contractor shall furnish and install the materials required to properly seal all roof penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof including roof pads that may be required to protect the roof under each of the lightning protection components.

2.6 GROUND ELECTRODES

A. Each down conductor shall terminate at a ground electrode dedicated to the lightning protection system, or to a building or facility ground electrode system that consists of multiple ground electrodes that are interconnected with a ground ring conductor.

B. Ground rod electrodes shall be copper-clad steel, a minimum 5/8" diameter and 10 feet long. The down conductor shall be connected to the ground electrode using a bronze ground rod clamp having a minimum of 1½" contact between the ground rod electrode and the conductor measured parallel to the axis of the ground rod electrode, or by an Ultraweld exothermically welded connection. Ground rod electrodes shall be located a minimum of 2 feet below grade and shall be installed below the frost line where possible (excluding shallow topsoil conditions).
C. Where it is not possible to drive ground rod electrodes because of bedrock or shallow topsoil conditions, ground plate electrodes, radial electrodes, ground ring electrodes, concrete-encased electrodes, or combinations of these may be used in accordance with NFPA® 780.

D. Where the structural steel framework is utilized as down conductors for the system, ground electrodes shall be connected to columns around the perimeter of the structure at intervals averaging not more than 60 feet apart. Columns shall be grounded using either bonding plates having 8 square inches of surface contact area or by Ultraweld® exothermically welded connections.

2.7 COMMON BONDING OF GROUNDED SYSTEMS

A. Common bonding of all grounded systems within the building shall be ensured by interconnecting them to the lightning protection system using main size conductor and fittings.

B. For structures exceeding 60 feet in height, the interconnection of the lightning protection system ground electrodes and other grounded systems shall be in the form of a ground loop conductor.

C. These grounded systems shall include but are not limited to the electrical service, communication, and antenna system grounds as well as all underground metallic piping systems including water, gas, sewer, underground metallic conduits, etc. Interconnection to a gas line shall be made on the customer's side of the meter.

2.8 POTENTIAL EQUALIZATION

A. Grounded metal bodies located within the required bonding distance as determined by the bonding distance formula in NFPA® 780 shall be bonded to the lightning protection system using the required bonding conductors and connections.

PART 3. EXECUTION

3.1 INSTALLATION

A. The installation of the lightning protection system shall be done in a neat and workmanlike manner.

B. The lightning protection system shall be installed by or under the supervision of a UL listed lighting protection installer.

C. The installers shall have completed factory training and be so certified by the manufacturer.

D. Install the lightning protection system in accordance with the approved coordinated shop drawing and the referenced lightning protection system installation standards. Any deviations shall be brought to the immediate attention of the manufacturer so as not to delay certification.
E. Splices and clamps: Install cable with as few joints as possible. Use approved exothermic welded connections for all above grade connections, ungrounded conductor splices and all underground connections between conductors and ground rods. Use approved mechanical compression connections for above grade connections with specific Owner approval only.

F. Systems shall be semi-concealed, with all down-lead conductors and groundings concealed within the building, but with roof conductors and air terminals exposed on roof. Where possible, roof conductors and air terminals shall be installed on inside faces of parapets so that they are not visible from below.

G. Copper downlead conductors shall be used even when aluminum is required on the roof. Downlead cables in conduit shall not be brought directly through the roof. Thru roof assemblies with solid brass or stainless steel rods shall be utilized for this purpose.

H. Ground Rods:
   1. Install rods by driving and not by drilling or jetting.
   2. Drive rods into unexcavated portions of the earth where possible.
   3. Where rods must be installed in excavated areas, drive rods into earth after compaction of backfill is completed.
   4. Drive to a depth such that the top of the rod will be approximately 18” below final grade or sub-grade.
   5. Bond exterior metal bodies on building to the lightning protection system.

I. Corrosion Protection:
   1. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings. Protect cable at all points where cable leaves concrete by wrapping rubber tape 2” on either side of the plane formed by the finished concrete surface.

3.2 COORDINATION

A. Coordinate the installation of the lightning protection system with other trades.

B. Coordinate all roof penetrations, fasteners and adhesive with the roofing contractor prior to installing any materials on the roof.

3.3 PROJECT DOCUMENTATION

A. Photo document all concealed portions of the lightning protection system as they are being installed. This includes lightning protection system grounding electrodes, connections to
LIGHTNING PROTECTION SYSTEM

structural metal, connections to underground metal piping entering the structure, connections to electrical and electronic service grounds, ground rings, etc. This documentation should be authenticated by the Owner or his representative.

B. Maintain accurate “as-built” drawings throughout the entire installation of the lightning protection system.

3.4 INSPECTION, CERTIFICATION AND MAINTENANCE

A. At completion of the installation of the lightning protection system, the contractor shall apply for inspection of the system by UL field representatives. The system is to be inspected for compliance with NFPA® 780.

B. If the lightning protection system covers an entire independent structure and the system passes inspection, UL will issue a Master Label® Certificate of Inspection for Lightning Protection System. The contractor will submit the certificate for distribution to the premises’ Owner. For the certificate to be valid, the contractor must publish the certificate to the UL website, https://lps.ul.com where it may be viewed by consumers, building owners, insurance agencies and other interested parties. The Master Label® Certificate of Inspection is valid for a period of five years. If the building changes structurally or if modifications are made to the system during that period, the certificate is no longer valid.

C. At project closeout, the contractor shall provide the Owner with accurate as-built drawings as well as recommended guidelines for maintenance of the system.

END OF SECTION 26 41 00
SECTION 26 51 00- LIGHTING

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections apply to the work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to the work in this Section.

1.2 DESCRIPTION OF WORK

A. Types of interior and exterior lighting fixtures in this Section include the following:

1. LED

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of interior and exterior light fixtures of types and ratings required, whose products have been in satisfactory use in similar service for not less than three years.

B. Installer: Qualified with at least three years of successful installation experience on projects with interior and exterior lighting fixture work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with the NEC as applicable to the installation and construction of lighting fixtures.

B. NEMA Compliance: Comply with applicable requirements of NEMA Standard Pub. Nos. LE-1 and LE-2 pertaining to lighting equipment.

C. ANSI/UL Compliance: Comply with ANSI/UL Standards pertaining to interior and exterior lighting fixtures for hazardous locations.

D. UL Compliance: Provide light fixtures that have been UL listed and labeled.

E. CBM Labels: Provide fluorescent lamp ballasts that comply with Certified Ballast Manufacturers Association Standards and carry the CBM label.
F. NECA Compliance: Comply with NECA's "Standard of Installation".

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's product data on lighting fixtures.

B. SHOP DRAWINGS

1. Furnish shop drawing portfolios (collated bound sets) containing the following information:

   a. Name of manufacturer
   b. Descriptive cut sheets
   c. Complete photometric information
   d. Coefficient of utilization tables
   e. Fixture voltage
   f. The number, type and wattage of the fixture lamps
   g. Lens types
   h. Fixture options
   i. Fixture mounting details
   j. Fixture door types
   k. Construction of fixture housing and/or door
   l. Fixture ballast manufacturer and type

2. All lighting fixtures required to be used on this project shall be submitted in one single submittal so that all fixtures can be reviewed at one time. Those fixtures not receiving a shop drawing action of "Reviewed" or "Reviewed and Noted" on the first submittal shall be resubmitted for review. A light fixture receiving a shop drawing action of "Resubmit" or "Rejected" after the third review for any reason, shall be furnished as originally specified.

3. The portfolios shall be made from standard manufacturer's specification sheets. Each fixture shall be identified by the letter or number indicated on the fixture schedule. The combining of more than one fixture type of fixture on a single sheet shall not be acceptable.

1.6 EXTRA MATERIALS

A. At substantial completion of the project, furnish the following extra materials that match specified and installed products to the Owner for future use after completion of project warranty periods. Extra materials shall be delivered and stored at a location or locations directed by the Owner. Products shall be packaged with protective covering for storage and shall be suitably labeled by product type.

1. Provide ten extra lamps for every 100 lamps (of each rating and type) installed on the project. Provide a minimum of at least one extra lamp for each lamp type and rating used.
2. Provide one extra lens and one extra louver for every 100 units (of each type) installed on the project. Provide a minimum of at least one extra lens and one extra louver for each type used.

3. Provide one extra ballast for every 100 units (of each type) installed on the project. Provide a minimum of at least one extra ballast for each type used.

2. PRODUCTS

2.1 Manufacturer: Manufacturers of lighting fixtures are noted on the drawings by notes and/or by the light fixture schedule.

2.2 Substitutions: If the Contractor proposes to substitute lighting fixtures for those shown on the drawings or specified herein, he shall submit a list of proposed fixtures together with technical data to substantiate that the substitute fixtures are equivalent in all respects to the specified equipment. Proposed substitute fixtures must be submitted to the architect/engineer for review a minimum of ten (10) days prior to the project bid date. Only original documentation will be accepted for review. After review of the proposed substitute fixtures, an addendum or bid bulletin will be issued to include acceptable equipment. The review of substitute equipment in no way relieves the contractor of the responsibility to provide equipment that is equivalent in all respects to specified fixtures. Lighting fixtures as shown on the drawings or specified herein shall be used as a basis and standard of comparison in the review and consideration of fixtures of other manufacturers. The Architect/Engineer shall have the final authority as to whether the fixture is equivalent to the specified item. The proposed substitution may be rejected for the aesthetic value if felt necessary or desirable. In the event the proposed substitutions are rejected, the Contractor shall furnish the specified item.

2.3 LED Drivers

A. Driver shall operate from 60 Hz input source of 120V through 277V with sustained variations of +/- 10 percent (voltage and frequency).

B. Driver input current shall have Total Harmonic Distortion (THD) of less than 20 percent when operated at nominal line voltage.

C. Driver shall have a Power Factor greater than 0.90.

D. Driver shall avoid interference with infrared devices and eliminate visible flicker.

E. Driver shall comply with ANSI C62.41 Category A for Transient protection.

F. Driver shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
G. The luminaire shall be capable of continuous dimming over a range of 100% to 5% of rated lumen output. Dimming shall be controlled by a 0-10VDC signal.

H. Control device must be compatible with type of driver, and coordinated prior to submission of shop drawings.

I. If driver is remote-mounted, provide maximum allowable distances for secondary wire runs to luminaires.

J. Provide with mounting hardware as required.

2.4 LED’s

A. Color temperature specified shall be uniform for all LED modules within like luminaire types. Color temperature measurement shall have a maximum 2 SDCM on the MacAdam Ellipse.

B. Correlated color temperature of 3500K unless otherwise specified. Minimum color rendering index (CRI) of 85.

C. LED light output and efficacy shall be measured in accordance with IES LM-79 standards.

D. LED life and lumen maintenance shall be measured in accordance with IES LM-80 standards.

E. Rated minimum life of 50,000 hours.

F. The individual LED’s shall be connected such that a catastrophic loss or the failure of one LED will not result in a light output loss of the entire luminaire.

2.5 PLASTER FRAMES

A. Standard plaster frames shall be provided for all recessed lighting fixtures installed in plaster or drywall finished walls or ceilings. Coordinate with architectural drawings.

2.6 THERMAL PROTECTION

A. All recessed incandescent and H.I.D. light fixtures shall be provided with thermal protection per N.E.C requirements.

3. EXECUTION

3.1 INSTALLATION
A. Install lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer’s written instructions, applicable requirements of the NEC, NECA’s "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

B. Coordinate with other electrical work as appropriate to properly interface installation of lighting fixtures with other work.

C. Adjust and Clean: Clean lighting fixtures of dirt and debris upon completion of the installation. Protect installed fixtures from damage during the remainder of the construction period.

D. Field Quality Control: Upon completion of the installation of lighting fixtures, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

E. Lighting fixture supports: Properly support and install fixtures in strict accordance with all applicable building codes and standards. Fully and completely coordinate the installation of fixtures with actual ceiling systems, and with all building trades. In general, provide fixture supports according to the following (unless applicable codes require more restrictive support details):

1. All lighting fixtures installed in grid type suspended ceiling systems, shall be positively attached to the ceiling system with clips that are UL listed for the application. In addition, a minimum of four (4) ceiling support system rods or wires shall be provided for each light fixture and shall be installed not more than six (6) inches from fixture corners. Provide two (2) No. 12 gage hangers from each fixture housing to the building structure above (wires may be installed slack). Light fixtures that weigh more than 56 pounds shall be supported directly from the structure above by UL listed and approved hangers. Light fixtures that are smaller than the ceiling grid shall be installed at locations indicated on the reflected ceiling plans, or shall be installed in the center of the ceiling panel and shall be supported independently by at least two metal channels that span and are secured to the ceiling system.

2. Suspended lighting fixtures shall be supported directly from the building structure without using suspended ceilings as support systems. Support systems shall be UL listed and approved for the specific installation. Where pendants or rods exceed 48 inches in length, brace support systems to limit swinging.

F. Adjust all fixture sockets to match the lamp specified and aim all adjustable fixtures as directed by the Architect/Engineer.

G. Square and rectangular fixtures shall be mounted with sides parallel to building and ceiling lines, unless otherwise noted.
H. Where special fixtures to be used in special ceilings are scheduled, verify all ceiling system details and coordinate fixture type and accessories prior to ordering fixtures. Coordinate and cooperate with ceiling system supplier in the preparation of ceiling system shop drawings.

I. Install fixtures as recommended by the manufacturer, or as necessary to provide exact horizontal alignment, preventing horizontal or vertical deflection, or angular jointing of fixtures suspended in continuous rows.

END OF SECTION 26 51 00
SECTION 27 00 00 - TELECOMMUNICATIONS

PART 1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to work specified in this Section.

PART 2. BUILDING WIRING SYSTEM DESIGN

2.1 GENERAL INFORMATION

A. Except for pathway construction, Division of IT will provide all material and equipment. This includes cable, voice/data/catv outlets and faceplates, equipment racks, and electronic equipment and all miscellaneous hardware.

B. The contractor will install owner-provided cable.

C. Cables do not need to be labeled by the contractor.

D. Division of IT will terminate, label and test all cabling and install all electronic equipment.

E. Cat6A shall be installed directionally from the telecom room outward.

PART 3. HORIZONTAL PATHWAYS AND SPACES

3.1 GENERAL INFORMATION

A. To avoid electromagnetic interference (EMI), all pathways shall provide clearances of at least 4 feet from motors or transformers, 1 foot from conduit and cables used for electrical power distribution, 5 inches from fluorescent lighting.

B. Horizontal Pathways:

1. Pathways must support cables and provide protection. Pathways should be planned to facilitate original installation as well as ongoing maintenance, additions, and relocations.
2. Conduit, trays, or other pathway hardware are to be used above the ceilings. Appropriate design of horizontal pathways should accommodate the hanging of cables loosely above suspended ceilings requires appropriate hardware (J-hooks, rings, etc.). Support hardware must not have sharp edges.

3. Cable trays should have twelve (12) inches of clearance above the tray. The designer should ensure that other building components (e.g., lighting fixtures, structural supports, air ducts) do not restrict access to the cable tray.

4. Cable routing, support, and sealing of penetrations must meet applicable UMC codes.

5. EZ Path series 44 fire wall sleeves are required where a cable tray path crosses a firewall. The quantity of EZ Path series 44 fittings will equal the capacity of the cable tray, not just the initial cabling demands.

6. Conduit, cable tray, and J-hooks will be designed to allow a 40% growth.

7. Hanging cable supports must be no more than 5 feet apart as the installed cable must exhibit some sag in hanging. This provides visual evidence that cable tension is within 25 pounds as required in EIA-568-A.

8. Bundles of cables supported by typical J-hooks should not be larger than 50 cables, unless additional support is provided.

9. Horizontal pathway design should take into consideration the horizontal cabling distance limitations of 90 meters (295 feet) from the telecommunications room to the outlet.

10. When conduit is used, sections of conduit shall be no longer than 150 ft and must not have more than or the equivalent of 270° bends between pull points or pull boxes.

11. Conduit inside bend radius must be:

<table>
<thead>
<tr>
<th>Conduit size…</th>
<th>Bend radius…</th>
</tr>
</thead>
<tbody>
<tr>
<td>2” or less</td>
<td>Six times the inside diameter</td>
</tr>
<tr>
<td>More than 2”</td>
<td>Ten times the inside diameter</td>
</tr>
</tbody>
</table>

12. Pull boxes should be placed directly after a bend or sized accordingly if the pull box is located at the bend.

13. Conduit fill limits must be followed to avoid over-packing cables:

<table>
<thead>
<tr>
<th>Conduit Size…</th>
<th># of cables…</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>3 cables max</td>
</tr>
<tr>
<td>1-1/4”</td>
<td>4 cables max</td>
</tr>
<tr>
<td>1-1/2”</td>
<td>6 cables max</td>
</tr>
<tr>
<td>2”</td>
<td>12 cables max</td>
</tr>
<tr>
<td>3”</td>
<td>20 cables max</td>
</tr>
</tbody>
</table>

14. Dual channel raceway such as Wiremold 4000 a decora (GFCI) style device plate opening.

15. When possible, outlet locations should be placed above the work surfaces for easy access. Outlet boxes built into the floor are not recommended.
16. Cabling shall be supported above drop ceiling completely by cable tray or J-hooks.

PART 4. CABLING INSTALLATION AND DISTRIBUTION

4.1 CABLE TYPE, SOURCE OF MATERIALS, AND ASSIGNMENT OF TASKS

A. All vertical and horizontal in-building cable shall be plenum rated.

B. All cable will terminate in a telecom room on the same floor as the outlet.

C. Division of IT will install all backbone cable and perform terminating and testing of such facilities.

D. The contractor shall install owner provided cabling as specified for the project. The Division of IT will terminate and test all contractor installed cabling. Division of IT will provide all materials including cable, connecting hardware, terminals, equipment racks, etc.

E. The contractor/installer shall take into account the following critical installation practices when installing telecommunications cabling.

1. Physical separation from all sources of EMI is critical. Sources of EMI include but are not limited to: motors, transformers, copiers, construction equipment, and branch circuit power cables. Cabling that leaves physical pathways and extends into office areas must not lay on fluorescent lighting.

2. Conduit or other raceway pulling tensions should be minimized using suitable equipment and practices.

3. Cables must not lie on or be suspended from suspended ceiling support wires or frames.

4. Eliminate cable stress caused by tension in suspended cable runs. Cables must exhibit some sag in hanging between supports. Hanging supports, such as J-hooks, must be within 5 feet of each other.

5. Cables bundles should not be larger than 50 cables and shall not be tightly cinched together. Tie wraps must be hand tightened without tools. Cables must never be twisted.

6. Installations of CAT6A cable should have bend radii less than six (6) times the cable diameter. For fiber optic cable, the minimum recommended bend radius is ten (10) times the cable diameter, twenty (20) times the cable diameter if loaded.

7. Cables shall not be spliced under any circumstances. Damaged or broken cables must be completely replaced or decommissioned with a label attached at both ends.

8. Conduits should not be daisy chained together.

9. Provide adequate slack at both ends to accommodate terminations:

<table>
<thead>
<tr>
<th>Location</th>
<th>Slack length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet</td>
<td>18 inches</td>
</tr>
<tr>
<td>Telecom Room</td>
<td>20 feet past termination point</td>
</tr>
</tbody>
</table>
END OF SECTION 27 00 00
SECTION 28 31 11 – ADDRESSABLE FIRE ALARM SYSTEM

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Sections:

1. Division 01 General Requirements
2. Division 07 Thermal and Moisture Protection, Penetration Firestopping
3. Division 08 Openings, Door Hardware
4. Division 21 Fire Suppression
5. Division 23 Heating Ventilating and Air Conditioning Monitoring & Control (HVAC).
6. Division 26 Electrical

1.2 SUMMARY

A. Section Includes:

1. This specification describes an addressable Fire Detection and alarm signaling system. The control panel shall be intelligent device addressable, analog detecting, low voltage and modular, with digital communication techniques, in full compliance with all applicable codes and standards. The features and capacities described in this specification are required as a minimum for this project and shall be furnished by the successful contractor.

2. The system shall be in full compliance with National and Local Codes.

3. The system shall include all required hardware, raceways, interconnecting wiring and software to accomplish the requirements of this specification and the contract drawings, whether or not specifically itemized herein.

4. All equipment furnished shall be new and the latest state of the art products of a single manufacturer, engaged in the manufacturing and sale of analog fire detection devices for over ten years.

5. The system as specified shall be supplied, installed, tested and approved by the local Authority Having Jurisdiction, and turned over to the owner in an operational condition.

6. In the interest of job coordination and responsibilities the installing contractor shall contract with a single supplier for fire alarm equipment, engineering, programming, inspection and tests for the complete system.

7. The system specified shall be that of Siemens Fire Safety which meets the project requirements.
1.3 DEFINITIONS

A. ASME: American Society of Mechanical Engineers

B. FACP: Fire Alarm Control Panel

C. FM: FM Global (Factory Mutual)

D. Furnish: To supply the stated equipment or materials.

E. Install: To set in position and connect or adjust for use.

F. LED: Light-emitting diode.

G. NCC: Network Command Center

H. NFPA: National Fire Protection Association. Definitions in NFPA 72 apply to fire alarm terms used in this Section.


J. Provide: To furnish and install the stated equipment or materials.

K. UL: Underwriters Laboratories.

1.4 SYSTEM DESCRIPTION

A. Desigo Modular with Digital Voice Evacuation - The system shall be complete, electrically supervised fire detection and evacuation system using one way communication and Firefighters telephone and smoke control systems with microprocessor based operating system having the following capabilities, features and capacities:

1. Voice amplification shall be supervised and backed up with like amplifiers. Back up shall be one for one. Backup amplifiers shall not share components and must be fully stand-alone.

2. Amplifiers shall be rated for 25V or 70.7V RMS.

3. Amplifiers shall be sized as minimum, to accommodate speakers at 1 watt except in gymnasiums, which shall be sized as minimum, to accommodate speakers at 4 watts.

4. The local system shall provide status indicators and control switches for all of the following functions:
a. Audible and visual notification alarm circuit zone control.
b. Speaker circuit zone control.
c. Status indicators for sprinkler system waterflow and valve supervisory devices.
d. Any additional status or control functions as indicated on the drawings, including but not limited to emergency generator functions, fire pump functions, door unlocking and security with bypass capabilities.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with NFPA 72 and all contract documents and specifications requirements.

B. System shall be a complete, supervised, noncoded, addressable multiplex fire alarm system conforming to NFPA 72.

C. The system shall operate in the alarm mode upon actuation of any alarm initiating device. The system shall remain in the alarm mode until all initiating device(s) are reset and the fire alarm control panel is manually reset and restored to normal.

D. The system shall provide the following functions and operating features:

1. The FACP and auxiliary power panels shall provide power, annunciation, supervision and control for the system.
2. Provide Class B initiating device circuits.
3. Provide Class B notification appliance circuits. Arrange circuits to allow individual, selective, and all-call voice and visual notification by zone. Notification Appliance circuits shall be zoned to correspond with the building fire barriers and other building features.
4. Stairtowers: Each Stairtower NAC shall be separately zoned.
5. Strobes shall be synchronized throughout the entire building.
6. If a voice evacuation system is specified, the system amplifiers shall be configured as distributed, bulk, or a combination of distributed and bulk audio. If necessary, convenience paging and/or background music shall be available via UL-listed speakers.
7. Provide 2 channel for live and recorded voice messaging.
8. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.

E. The system shall provide a field test function where one person can test the complete system or a specific area while maintaining full operational function of other areas not being tested. Alarms, supervisory signals, trouble signals shall be logged on the system printer and in system history during the walk-test.

F. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.
G. Fire alarm signal initiation shall be by one or more of the following devices:

1. Manual pull station
2. Heat detector
3. FirePrint® Addressable area smoke detector
4. Duct smoke detector (see the fire alarm general notes on the drawings)
5. Automatic sprinkler system water flow switch

H. Activation of any system fire, security, supervisory, trouble, or status initiating device shall cause the following actions and indications at all network Person Machine Interfaces using basic graphics and multiple detail screens.

1. Fire Alarm Condition:
   a. Sound an audible alarm and display a custom screen/message defining the building in alarm and the specific alarm point initiating the alarm in a graphic display.
   b. Log into the system history archives all activity pertaining to the alarm condition.
   c. Sound the ANSI 117-1 signal with synchronized audibles and synchronized strobes throughout the facility.
   d. Audible signals shall be silenced from the fire alarm control panel by an alarm silence switch. Visual signals shall be programmable to flash until system reset or alarm silencing, as required.
   e. A signal dedicated to sprinkler system water flow alarm shall not be silenced while the sprinkler system is flowing at a rate of flow equal to a single head.
   f. Where indicated on drawings heat detectors in elevator shaft and machine rooms shall activate an elevator power shunt trip breaker. The heat detectors shall be rated at a temperature below the ratings of the sprinkler heads in respective locations to insure that the power shall be shut off before activation of sprinkler system.
   g. System operated duct detectors as per local requirements shall accomplish HVAC shut down. See the fire alarm general notes on the drawings.
   h. Door closure devices shall operate by floor or by local requirements.

2. Additional system operation for Fire Alarm Condition for Voice:
   a. Sound a pre-announce tone followed by a field programmable digitized custom evacuation message.
   b. An automatic announcement or tone evacuation signal shall be capable of interruption by the operation of the system microphone to give voice evacuation instructions overriding the pre-programmed sequences.
   c. Status lights next to speaker selection switches on the control panel shall indicate speaker circuit selection.
d. Audible signals shall be silenced from the fire alarm control panel by an alarm silence switch. Visual signals shall be programmed to flash until system reset or alarm silencing, as required by the AHJ.

3. Supervisory Condition:
   a. Display the origin of the supervisory condition report at the local fire alarm control panel graphic LCD display.
   b. Activate supervisory audible and dedicated visual signal.
   c. Audible signals shall be silenced from the control panel by the supervisory acknowledge switch.
   d. Record within system history the initiating device and time of occurrence of the event.

4. Trouble Condition
   a. Display at the local fire alarm control panel graphic LCD display, the origin of the trouble condition report.
   b. Activate trouble audible and visual signals at the control panel and as indicated on the drawings.
   c. Audible signals shall be silenced from the fire alarm control panel by a trouble acknowledge switch.
   d. Trouble conditions that have been restored to normal shall be automatically removed from the trouble display queue and not require operator intervention. This feature shall be software selectable and shall not preclude the logging of trouble events to the historical file.
   e. Trouble reports for primary system power failure to the master control shall be automatically delayed for a period of time equal to 25% of the system standby battery capacity to eliminate spurious reports as a result of power fluctuations.
   f. Record within system history, the occurrence of the event, the time of occurrence and the device initiating the event.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Complete manufacturer’s catalog data including supervisory power usage, alarm power usage, physical dimensions, and finish and mounting requirements.

B. Power calculations. Battery capacity calculations. Battery size shall be a minimum of 125% of the calculated requirement. Provide the following supporting information:
   1. Supervisory power requirements for all equipment.
2. Alarm power requirements for all equipment.
3. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst-case condition plus 20% spare capacity.
4. Voltage drop calculations for wiring runs demonstrating worst-case condition.
5. NAC circuit design shall incorporate a 15% spare capacity for future expansion.

C. Submit manufacturer’s requirements for testing Device Loop Card circuits and device addresses prior to connecting to control panel. At a minimum the following tests shall be required; device address, the usage (Alarm, Supervisory etc), environmental compensation, temperature ratings for thermal detectors and smoke detector sensitivities. This requirement shall need approval before any wiring is connected to the control panel.

D. Shop Drawings: Include plans, elevations, sections, details and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Complete drawings covering the following shall be submitted by the contractor for the proposed system:
      a. Floor plans in a CAD compatible format at a scale of 1/8"=1'-0" showing all equipment and raceways, marked for size, conductor count with type and size, showing the percentage of allowable National Electric Code fill used.
      b. Provide a fire alarm system function matrix as referenced by NFPA 72, Figure A-7-5.2.2 (9). Matrix shall illustrate alarm input/out events in association with initiation devices. Matrix summary shall include system supervisory and trouble output functions. Include any and all departures, exceptions, variances or substitutions from these specifications and/or drawings at time of bid.
   4. An individual experienced with the work specified herein and supervised by a NICET level IV technician shall prepare installation drawings, shop drawings and as-built drawings. Include name and certification number of supervising NICET level IV technician as part of the project submittals.
   5. Incomplete submittals shall be returned without review, unless with prior approval of the Engineer.

E. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Light fixtures.
   2. HVAC registers.
   3. Fire protection equipment interfaces.
4. Special suppression system interfaces.

F. Qualification Data: For qualified Installer, Applicator, manufacturer, fabricator, professional engineer, testing agency, and factory-authorized service representative.

G. Operation and Maintenance Data: For all fire alarm equipment, to include in operation and maintenance manuals.

H. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

I. Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace fire alarm equipment that fail(s) in materials or workmanship within specified warranty period.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: The publications listed below form a part of this publication to the extent referenced. The publications are referenced in the text by the basic designation only. The latest version of each listed publication shall be used as a guide unless the authority having jurisdiction has adopted an earlier version.

   1. FM Global (Factory Mutual (FM)):FM Approval Guide
   2. National Fire Protection Association (NFPA)
      a. NFPA 70 National Electrical Code
      b. NFPA 72 National Fire Alarm Code
      c. NFPA 90A Standard For The Installation of Air Conditioning and Ventilating Systems
      a. UL Fire Protection Equipment Directory
      b. UL Electrical Construction Materials Directory
      c. UL 38 – Manually Actuated Signaling Boxes for Use With Fire Protection Signaling Systems
      d. UL 228 – Door Holding Devices
      e. UL 268 - Smoke Detectors for Fire Protective Signaling Systems
f. UL 268A - Smoke Detectors for Duct Application
g. UL 464 - Audible Signal Appliances
h. UL 497A – Secondary Protectors for Communications Circuits
i. UL 521 - Heat Detectors for Fire Protective Signaling Systems
j. UL 864 - Control Units for Fire Protective Signaling Systems
k. UL 1283 – Electromagnetic Interference Filters
l. UL 1449 - Transient Voltage Surge Suppressors
m. UL 1480 - Speakers for Fire Protective Signaling Systems
n. UL 1971 - Signaling Devices for the Hearing Impaired

4. Underwriters Laboratories Canada (ULC)
5. International Code Council
   a. International Building Code

6. State and Local Building Codes as adopted and/or amended by The Authority Having Jurisdiction, ADA, and/or State and local equivalency standards as adopted by The Authority Having Jurisdiction.
7. ISO 9002

B. Supplier Qualifications
   1. Provide the services of a factory trained and certified representative or technician for system design/drawing preparation, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State if required by law and be a NICET level IV technician. Include name and certification number of NICET level IV technician as part of the project submittals.
   2. The technician site shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall be licensed in the State if required by law and be a NICET level II technician. The technician shall provide the required instruction to the owner's personnel in the system operation and maintenance.
   3. The supplier shall furnish evidence they have an experienced service organization, located within 50 miles of the project site, which carries a stock of spare and repair parts for the system being furnished.

C. Installer Qualifications:
   1. Before commencing work, submit data showing that the manufacturer has successfully installed fire alarm systems of the same scope, type and design as specified.
   2. The contractor shall submit copies of all required Licenses and Bonds as required in the State having jurisdiction.
   3. The contractor shall employ on staff a minimum of one NICET level IV technician or a professional engineer, registered in the State of the installation.
4. Contractors unable to comply with the provisions of Qualification of Installers shall present proof of engaging the services of a subcontractor qualified to furnish the required services.

D. Testing Agency Qualifications: Qualified for testing indicated.

E. Source Limitations for fire alarm equipment: Obtain fire alarm equipment from single source.

F. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Preinstallation Conference: Conduct conference at Project site.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacturer and shelf life if applicable.

B. Store materials inside, under cover, above ground, and kept dry and protected from physical damage until ready for use. Remove from site and discard wet or damaged materials.

1.9 PROJECT CONDITIONS

A. Installed products or materials shall be free from any damage including, but not limited to, physical insult, dirt and debris, moisture, and mold damage.

B. Environmental Limitations: Do not deliver or install products or materials until spaces are enclosed and weathertight, wet work in spaces is complete and dry, temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 WARRANTY
A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace fire alarm equipment that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year from date of Substantial Completion.

1.11 SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for 1 year.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

2. PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements shall be Siemens.

2.2 CONTROL PANEL

A. The fire alarm control panel shall be microprocessor based using multiple microprocessors throughout the system providing rapid processing of smoke detector and other initiation device information to control system output functions.

B. There shall be a watchdog circuit, which shall verify the system processors and the software program. Problems with either the processors or the system program the panel shall activate a trouble signal, and reset the panel.

C. The system modules shall communicate with an RS 485 network communications protocol. All module wiring shall be to terminal blocks, which will plug into the system card cage. Provide as a minimum two Style 4 isolated intelligent Signaling Line Circuits. Install addressable devices evenly on the intelligent Signaling Line Circuits so the load on each circuit is balanced for easy future expansion. All intelligent Signaling Line Circuits shall have 20% spare capacity as a minimum. Installing all addressable devices on one Style 4 isolated intelligent Signaling Line Circuit will not be permitted.

D. System Components:
1. Provide a Siemens Desigo Modular Voice addressable fire alarm/voice evacuation system with a supervised microphone and pre-amplifier. The microphone module shall contain 6 programmable switches contain a Local Speaker w/control, Ready to Page LED, and a Pre-Announcement tone LED. The module shall be mounted in the door for easy access and viewing.

2. The voice evacuation system must be integral to the fire alarm system. Separate "package" voice evacuation systems are not acceptable and will not be installed as part of this project.

E. System response time from alarm to output shall not exceed three (3) seconds.

F. To expedite system troubleshooting, the system cards shall have ground fault detection, and diagnostic LED’s by card.

G. All system cards and modules shall have Flash memory for downloading the latest module firmware.

H. Passwords:

1. Maintenance/Control Password - There shall be a 5 character password that a user must enter into the control panel in order to perform such maintenance- and control-related functions at the panel as:
   a. Arming and disarming devices.
   b. Activating, deactivating or modifying detector ASD and sensitivity settings.
   c. Activating and deactivating the History Log function, and deleting obsolete entries.
   d. Changing the system time and date.

2. Function Key Password - There shall be a 5 character password that a user must enter into the control panel in order to access the panel's Function Keys: touchscreen buttons which perform custom-programmed system functions.

3. Reports Password - There shall be a 5 character password that a user must enter into the control panel in order to access the panel's reporting functions.

4. Walktest Password - There shall be a 5 character password that a user must enter into the control panel in order to access the panel's walktesting functions.

5. Acknowledge Silenceable Reset Password - There shall be a 5 character password that a user must enter into the control panel in order to acknowledge events, turn silenceable audibles and visuals on and off, and perform panel resets.

I. Networking:

J. Degrade Mode Alarm Activation:
1. Each data gathering panel shall support the ability to have its corresponding ZIC-4A, ZIC-8B and output devices on a DLC’s loop activate when the DLC or CDC-4 is in Degrade Mode (has lost HNET communication with the PMI control panel). For example, if the device loop includes HFP detectors with relay bases and lamps, the relays and lamps will activate upon any system alarm when the DLC is in Degrade Mode.

2. Degrade Mode Alarm Activation with Voice: Each data gathering panel shall support the ability to have its corresponding DAC-NET turn on audio when the DLC or CDC-4 is in Degrade Mode (has lost HNET communication with the PMI control panel).

K. Digital Voice Command:

1. The Digital Voice Command Center located with the FACP, shall contain all equipment required for all audio control, emergency telephone system control, signaling and supervisory functions. This shall include speaker zone indication and control, telephone circuit indication and control, digital voice units, microphone and main telephone handset.

2. Up to 5 Digital Voice Command Centers shall be supported per system with the ability to limit control to one Digital Voice Command Center via a Request/Grant/Deny mechanism.

3. Function: The Voice Command Center equipment shall perform the following functions:

   a. Operate as a supervised multi-channel emergency voice communication system.
   b. Audibly and visually annunciate the active or trouble condition of every speaker circuit and emergency telephone circuit.
   c. Audibly and visually annunciate any trouble condition for digital tone and voice units required for normal operation of the system.
   d. Provide all-call Emergency Paging activities through activation of a single control switch.
   e. As required, provide vectored paging control to specific audio zones via dedicated control switches.
   f. Provide a factory recorded "library" of voice messages and tones in standard WAV. File format, which may be edited and saved on a PC.
   g. Provide a software utility capable of off-line programming for the VCC operation and the audio message files. This utility shall support the creation of new programs as well as editing and saving existing program files. Uploading or downloading the VCC shall not inhibit the emergency operation of other nodes on the fire alarm network.
   h. The Digital Voice Command shall be modular in construction, and shall be capable of being field programmable without requiring the return of any components to the manufacturer and without requiring use of any external computers or other programming equipment.
   i. The Digital Voice Command and associated equipment shall be protected against unusually high voltage surges or line transients.

L. Software Modifications: The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made. Systems that require the use of external programmers or change of EPROMs are not acceptable.
M. Logic: The fire alarm system shall support generic functions that deal with binary states (True/False, high/low), and produce desired outputs from one or more binary inputs (for example, alarm outputs from detector or manual station inputs). AND, OR, NOT, Any N, D Latch, RS Latch, Time Base Control, Start Timer, Restart Timer are generic functions. Generic functions can be used as inputs to other function. The system shall support 1500 logic functions.

N. History: The system shall store 5000 events in history while in straight mode and 4500 in circular mode. In straight mode, trouble warnings will occur at 4000 and 4500 events. In circular mode, the control panels shall maintain a 2000 event Alarm History buffer, which consists of the 2000 most recent alarm events from the 4500 event history file.

O. Reports:

1. The system shall have the ability to provide configuration, status, queue and history reports.
2. Configuration reports shall provide the following information:
   a. Custom Messages
   b. Database Information
   c. Entity Type
   d. Device Usage
   e. Device Category
   f. Firmware revision
3. Status reports shall provide the following information:
   a. Disarmed cards and devices
   b. ASD settings
   c. Sensitivity in %/foot
   d. Alarm threshold in %/foot
   e. Temperature in degrees C
   f. Walktest
4. Queue reports shall provide the following information:
   a. Alarm events with custom messages and event time
   b. Supervisory events with custom messages and event time
   c. Security events with custom message and event time
   d. Trouble events with custom message and event time
5. History reports shall provide Address, History Type, Description, Time & Date and Custom Message. The following event types shall be reported:
2.3 POWER SUPPLY

A. The system Power Supply/Charger (PSC) shall be a 12-amp supply with battery charger. The power supply shall be filtered and regulated. The power supply shall have a minimum of 1 power limited output rated at 4 amps, and a minimum of 1 output rated at 12 amps. The system power supply can be expanded up to 48 amps. The auxiliary power supply module shall share common batteries with the primary power supply. The system power supply shall have 4 relays, 1 for common alarm, one for common trouble and two programmable relays. The power supply shall be rated for 120/240 VAC 50/60 Hz. The module shall be model number PSC-12 or PSX-12.

B. The battery charger shall be able to charge the system batteries up to 100 AH batteries. Battery charging shall be microprocessor controlled and programmed with a special software package to select charging rates and battery sizes. An optional Thermistor for monitoring battery temperature to control charging rate shall be available.

C. The power supply shall have a plug for an AC adapter cable, which allows a technician to plug in a laptop computer for up or down loading program information or test equipment.

D. Transfer from AC to battery power shall be instantaneous when AC voltage drops to a point where it is not sufficient for normal operation.

2.4 SYSTEM ENCLOSURE
A. Provide the enclosure needed to hold all the cards and modules as specified with at least spare capacity for two cards. The enclosure outer door shall be either black or red. Provide the color as to the local AHJ requirements. The outer doors shall be capable of being a left hand open or a right hand open. The inner door shall have a left hand opening. System enclosure doors shall provide where required ventilation for the modules or cards in the enclosure.

B. Provide system enclosure for all amplifiers. Where required by the manufacturer, provide means for venting heat from the enclosure either by having enclosure sides and top vented or the doors vented.

2.5 INITIATING DEVICES

A. Intelligent Initiation Devices – General

1. All initiation devices shall be insensitive to initiating loop polarity. Specifically, the devices shall be insensitive to plus/minus voltage connections on either Style 4 or Style 6 circuits.

B. Smoke Detectors – Addressable

1. The detector shall be guaranteed in writing not to false alarm when configured by the factory trained certified technician. The detector must provide up to 11 different environmental algorithms that allow the detector to provide superior false alarm immunity without the need for additional alarm verification delays.

2. The detector shall have a multicolor LED to streamline system maintenance/inspection by plainly indicating detector status as follows: green for normal operation, amber for maintenance required, red for alarm.

3. The multi-criteria smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. So as to minimize the effort required by the installing and maintenance technician to appropriately configure the detector to ensure optimal system design, the detectors shall be programmable as application specific. Application settings shall be selected in software for a minimum of eleven environmental fire profiles unique to the devices installed location.

4. The detector shall be designed to eliminate the possibility of false indications caused by dust, moisture, RFI/EMI, chemical fumes and air movement while factoring in conditions of ambient temperature rise, obscuration rate changes and hot/cold smoke phenomenon into the alarm decision to give the earliest possible real alarm condition report.

5. The intelligent smoke detector shall be capable of providing three distinct outputs from the control panel. The outputs shall be from an input of smoke obscuration, a thermal condition or a combination of obscuration and thermal conditions. The detector shall be designed to eliminate calibration errors associated with field cleaning of the chamber.
6. The detector shall support the use of a relay, or LED remote indicator without requiring an additional software address. Low profile, white case shall not exceed 2.5 inches of extension below the finish ceiling.

7. Detector wiring shall not require any special shielded cable. For the detector where required, there shall be available a locking kit and detector guard to prevent unauthorized detector removal.

8. The smoke detector shall be Siemens model number FDOOT441

9. Where required, there shall be available a programmable remote lamp configurable to remotely duplicate the on-board LED status of another system device with the same software address. It shall be model ILED-H.

C. Heat Detectors – Addressable

1. Thermal Detectors shall be rated at 135 degrees fixed temperature and 15 degrees per minute rate of rise. Detectors shall be constructed to compensate for the thermal lag inherent in conventional type detectors due to the thermal mass, and alarm at the set point of 135 degrees Fahrenheit. The choice of alarm reporting as a fixed temperature detector or a combination of fixed and rate of rise shall be made in system software and be changeable at any time without the necessity of hardware replacement.

2. The detectors furnished shall have a listed spacing for coverage up to 2,500 square feet and shall be installed according to the requirements of NFPA 72 for open area coverage. The thermal detector shall be Siemens model number FDT421.

D. Duct Smoke Detectors – Addressable

1. For duct detector applications, the smoke detector shall be an intelligent digital photoelectric detector with a programmable heat detector. Detectors shall be listed for use as open area protective coverage, in duct installation and sampling assembly installation and shall be insensitive to air velocity changes.

2. The detector communications shall allow the detector to provide alarm input to the system and alarm output from the system within four (4) seconds. The detector shall be mounted in a duct detector housing listed for that purpose. The duct detector shall support the use of a remote test switch, relay or LED remote indicator. The duct detector shall be supplied with the appropriate sampling tubes to fit the installation.

3. Where duct detectors are exposed to the weather a weatherproof enclosure shall be available. The duct housing cover shall include a test port for functional testing of the detector without cover removal. The duct housing shall include a cover removal switch capable of indicating cover removal status to the fire alarm control panel.

4. The intelligent duct detector shall be Siemens model number FDBZ492. Where required there shall be available a duct housing with an on-board relay.

E. Detector Bases – Addressable
1. Detector bases shall be low profile twist lock type with screw clamp terminals and self-wiping contacts. Bases shall be installed on an industry standard, 4” square or octagonal electrical outlet box.

F. Manual Pull Stations – Addressable

1. Provide addressable manual stations where shown on the drawings, to be flush or surface mounted as required. Manual stations shall contain the intelligence for reporting address, identity, alarm and trouble to the fire alarm control panel. The manual station communications shall allow the station to provide alarm input to the system and alarm output from the system within less than four (4) seconds.

2. The manual station shall be equipped with terminal strip and pressure style screw terminals for the connection of field wiring. Surface mounted stations where indicated on the drawings shall be mounted using a manufacturer’s prescribed matching red enamel outlet box.

3. The double action pull station shall be Siemens model number HMS-D.

G. Addressable Interface Devices

1. Addressable Interface Devices shall be provided to monitor contacts for such items as water-flow, tamper, and PIV switches connected to the fire alarm system. These interface devices shall be able to monitor a single or dual contacts. An address will be provided for each contact. Where remote supervised relay is required the interface shall be equipped with a SPDT relay rated for 4 amps resistive and 3.5 amps inductive.

H. Device Programming Unit: The programming tool shall program the intelligent devices with addresses. The unit shall test the device to respond to its address. Dipswitches and rotary switches shall not be acceptable. The programmer shall be model DPU with carrying case. Provide Owner with one Device Programming Unit.

2.6 NOTIFICATION APPLIANCES

A. Series SL – Speaker and Speaker Strobes

1. Speaker appliances shall be Siemens Series SL Speakers, and the speaker-strobe appliances shall be Siemens Series SL Speaker Strobes. Speakers with a top power rating of two watts or less will not be permitted in gymnasiums.

2. Speakers shall be UL Listed under Standard 1480 for Fire Protective Service, and speakers equipped with strobes shall be listed under UL Standard 1971 for Emergency Devices for the Hearing-Impaired

3. Speaker with strobes shall be certified to meet the requirements of FCC Part 15, Class B

4. All speakers shall be designed for a field-selectable input of either 25 or 70 VRMS; with selectable power taps from 1/8 watt to 2 watts
5. All wall-mount models shall have listed sound output of up to 89 dBA at 10 feet and a listed frequency response of 400 to 4000 Hz
6. All ceiling-mount models shall have listed sound output of up to 87 dB at 10 feet and a listed frequency response of 400 to 4000 Hz
7. Speaker shall incorporate a sealed-back construction
8. All inputs shall employ terminals that accept #12 to #18 AWG wire sizes
9. Strobe intensity, where Multi-Candela appliances are specified, shall have field-selectable settings, and shall be rated per UL Standard 1971 for:
   a. 15/30/75/110cd (wall mounting)
   b. 135/185cd (wall mounting)
10. Strobe intensity, where Multi-Candela appliances are specified, shall have field-selectable settings, and shall be rated per UL Standard 1971 for:
    a. 15/30/75/110cd (ceiling mounting)
    b. 135/185cd (ceiling mounting)
11. Selector switch for selecting the candela shall be tamper resistant
12. The strobes shall not drift out of synchronization at any time during operation
13. The strobes shall revert to a non-synchronized flash-rate, if the sync module or Power Supply should fail to operate (i.e. contacts remain closed)
14. Wall-mount speaker and speaker-strobe appliances shall be designed for indoor-flush mounting to 4" x 2-1/8" electrical boxes without need for an extension ring or surface mounting
15. Ceiling-mount, speaker-strobe appliances shall be designed for indoor-flush mounting
16. Speaker and speaker strobe shall incorporate a speaker-mounting plate with a snap-on grille cover
17. The finish of the Series SL speakers and speakers strobes shall be white
18. All speaker and speaker-strobe appliances shall listed for Special Applications: Strobes are designed to flash at 1-flash-per-second minimum over their “Regulated Input Voltage Range”

2.7 CELLULAR/IP COMMUNICATOR

A. Cellular/IP fire communicators shall be a Starlink Fire SLE-LTEVI-FIRE and shall be installed in a separate enclosure. Communicator shall be powered by 24 VDC from a UL listed fire alarm control and shall report (4) conditions: alarm, trouble, supervisory alarm and waterflow alarm. The unit shall have built in auxiliary relay output which is programmable for alarm or trouble conditions, and shall be capable of transmitting a distinctive AC power failure signal.

B. The communicators shall have the following features: visual and audible trouble indications; supervised or unsupervised input channels; local and remote programming and automatic 24-hour test.
C. The communicators shall be UL 864 listed and meet the requirements of NFPA 72, chapter 4 for supervising station fire alarm systems.

D. Provide all necessary power and signaling cabling between the fire alarm panel and communicator as necessary for the required signaling.

2.8 REMOTE ANNUNCIATOR, SWITCH CONTROL MODULES AND LIVE VOICE MODULE

A. The System Status Display (SSD-C-REM) shall provide a remote LED/LCD display that shows the local status of a Desigo Modular system. An LED shall illuminate when alarm, supervisory, trouble and security events occur on the system. The SSD-C-REM shall consist of a LCD display that has four lines of forty characters each that provides details of the event in alphanumeric form. The SSD-C-REM shall have three additional control buttons for acknowledging events, silencing audible circuits, and resetting the system. The SSD-C-REM shall have the ability to be located within a locked cabinet, so no additional keyswitch is required for enabling the control buttons. The SSD-C-REM shall be mounted in a model REMBOX4 Remote Lobby Enclosure.

B. The Switch Control Module (SCM-8) shall be a supervised module with 8 switches and two LED’s per switch for controlling such items as speaker/strobe or telephone circuits, fire alarm drill activation/deactivation, etc. The switches shall also be used as generic inputs into the system. The SCM-8’s shall be mounted in the door for easy access. These modules shall be connected to the control area network, and have a maximum distance of 1000 ft. The module shall be mounted in the inner door of the REMBOX4 remote lobby enclosure. The module shall be model number SCM-8. One of the switches shall be used for a drill switch that shall initiate all devices and activate fire/smoke doors, but shall not shut down air handlers or close fire/smoke dampers.

C. The Live Voice Module (LVM) shall have the supervised Microphone and pre-amplifier. The module shall contain 6 programmable switches. The module shall connect to the control area network, and also connect to the PMI. The module shall have remote capability using a Remote Network Interface (RNI). The module requires a Local Page Board (LPB) to convert the audio to a digital signal. The module shall contain a Local Speaker w/control, Ready to Page LED, and a Pre-Announcement tone LED. The module shall be mounted in the inner door of the REMBOX4 remote lobby enclosure for easy access and viewing. The module shall be model number LVM.

D. A REMBOX4 remote lobby enclosure shall be provided to house the SSD-C-REM, SCM-8s, LVM, RNI and LPB modules. The REMBOX4 shall be 24” wide, 18-1/2” high and 5” deep.

3. EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Perform work in accordance with the requirements of NFPA 70, NFPA 72 and NECA 1-2006, Standard of Good Workmanship in Electrical Contracting.

B. Fasten equipment to structural members of building or metal supports attached to structure, or to concrete surfaces.

C. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway except in unfinished spaces.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer’s limitations on bending radii. Provide and use lacing bars and distribution spools.

E. Provide primary power for each panel from normal/ emergency panels as indicated on the Electrical Power Plans. Power shall be 120 VAC service, transformed through a two-winding, isolation type transformer and rectified to low voltage DC for operation of all circuits and devices.

3.3 BOXES, ENCLOSURES AND WIRING DEVICES

A. Boxes shall be installed plumb and firmly in position.

B. Extension rings with blank covers shall be installed on junction boxes where required.

C. Junction boxes served by concealed conduit shall be flush mounted.

D. Upon initial installation, all wiring outlets, junction, pull and outlet boxes shall have dust covers installed. Dust covers shall not be removed until wiring installation when permanent dust covers or devices are installed.

E. "Fire alarm system" decal or silk-screened label shall be applied to all junction box covers.

3.4 CONDUCTORS
A. Each conductor shall be identified as shown on the drawings at each with wire markers at terminal points. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.

B. All wiring shall be supplied and installed in compliance with the requirements of the National Electric Code, NFPA 70, Article 760, and that of the manufacturer.

C. Wiring for strobe and audible circuits shall be a minimum 14 AWG, signal line circuits; 18 AWG twisted shielded, speaker circuits; 18 AWG twisted, telephone circuit; 18 AWG twisted shielded.

D. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer recommendations.

E. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

F. The installation contractor shall submit for approval prior to installation of wire, a proposed color code for system conductors to allow rapid identification of circuit types.

G. Wiring within sub panels shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.

3.5 DEVICES

A. Relays and other devices to be mounted in auxiliary panels are to be securely fastened to avoid false indications and failures due to shock or vibration.

B. Wiring within panels shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.

C. All devices and appliances shall be mounted to or in an approved electrical box.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.

C. A consistent color code for fire alarm system conductors throughout the installation.
3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a Siemens factory branch service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Testing General:

1. All Alarm Initiating Devices shall be observed and logged for correct zone and sensitivity. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the initials of the installing technician and date. Label devices so the address is visible for maintenance and testing purposes.
2. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.
3. The acceptance inspector shall be notified before the start of the required tests. All items found at variance with the drawings or this specification during testing or inspection by the acceptance inspector shall be corrected.
4. Test reports shall be delivered to the acceptance inspector as completed.
5. All test equipment, instruments, tools and labor required to conduct the system tests shall be made available by the installing contractor. The following equipment shall be a minimum for conducting the tests:

   a. Ladders and scaffolds as required to access all installed equipment.
   b. Multi-meter for reading voltage, current and resistance.
   c. Two way radios, and flashlights.
   d. A manufacturer recommended device for measuring air flow through air duct smoke detector sampling assemblies.
   e. Decibel meter.
   f. In addition to the testing specified to be performed by the installing contractor, the installation shall be subject to test by the acceptance inspector.

3.8 ACCEPTANCE TESTING

A. A written acceptance test procedure (ATP) for testing the fire alarm system components and installation will be prepared by the engineer in accordance with NFPA 72 and this specification. The contractor shall be responsible for the performance of the ATP, demonstrating the function of the system and verifying the correct operation of all system components, circuits, and programming.

B. A program matrix shall be prepared by the installing contractor referencing each alarm input to every output function affected as a result of an alarm condition on that input.

C. The installing contractor prior to the ATP shall prepare a complete listing of all device labels for alphanumeric annunciator displays.
D. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests shall be witnessed by the Owner and test results recorded for use at the final acceptance test.

E. Preliminary Testing: Conduct preliminary tests to ensure that all devices and circuits are functioning properly. After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that all panel functions were tested and operated properly. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments.

F. Final Acceptance Test: Notify the Owner in writing when the system is ready for final acceptance testing. Submit request for test at least 14 calendar days prior to the test date. A final acceptance test will not be scheduled until megger test results, the loop resistance test results, and the submittals required in Part 1 are provided to the Owner. Test the system in accordance with the procedures outlined in NFPA 72.

1. Verify that the control unit is in the normal condition as detailed in the manufacturer's operating and maintenance manual.
2. Test each initiating and indicating device and circuit for proper operation and response. Disconnect the confirmation feature for smoke detectors during tests to minimize the amount of smoke or test gas needed to activate the detector.
3. Test the system for all specified functions in accordance with the contract drawings and specifications and the manufacturer's operating and maintenance manual.
4. Visually inspect all wiring.
5. Verify that all software control and data files have been entered or programmed into the FACP.
6. Verify that Shop Drawings reflecting as-built conditions are accurate.
7. Measure the current in circuits to assure that there is the calculated spare capacity for the circuits.
8. Measure voltage readings for circuits to assure that voltage drop is not excessive.
9. Measure the voltage drop at the most remote appliance on each notification appliance circuit.

G. The acceptance inspector shall use the system record drawings in combination with the documents specified in this specification during the testing procedure to verify operation as programmed. In conducting the ATP, the acceptance inspector shall request demonstration of any or all input and output functions. The items tested shall include but not be limited to the following:

1. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:

   a. Open, shorted and grounded signal line circuits.
b. Open, shorted and grounded notification, releasing circuits.
c. Primary power or battery disconnected.

2. System notification appliances shall be demonstrated as follows:
   a. All alarm notification appliances actuate as programmed
   b. Audibility and visibility at required levels.

3. System indications shall be demonstrated as follows:
   a. Correct message display for each alarm input at the control display.
   b. Correct annunciator light for each alarm input at each annunciator and graphic display as shown on the drawings.
   c. Correct history logging for all system activity.

4. System off-site reporting functions shall be demonstrated as follows:
   a. Correct zone transmitted for each alarm input
   b. Trouble signals received for disconnect

5. Secondary power capabilities shall be demonstrated as follows:
   a. System primary power shall be disconnected for a period of time as specified herein. At the end of that period, an alarm condition shall be created and the system shall perform as specified for a period as specified.
   b. System primary power shall be restored for forty-eight hours and system-charging current shall be normal trickle charge for a fully charged battery bank.
   c. System battery voltages and charging currents shall be checked at the fire alarm control panel.

3.9 DOCUMENTATION

A. System documentation shall be furnished to the Owner and shall include but not be limited to the following:

1. System record drawings and wiring details including one set of reproducible drawings, and a CD ROM with copies of the record drawings in DXF format for use in a CAD drafting program.
2. System operation, installation and maintenance manuals.
3. System matrix showing interaction of all input signals with output commands.
4. Documentation of system voltage, current and resistance readings taken during the installation, testing and ATP phases of the system installation.
5. System program showing system functions, controls and labeling of equipment and devices.

3.10 PROTECTION

A. Remove and replace devices and panel components that are wet, moisture damaged, or mold damaged.

3.11 DEMONSTRATION

A. Instructor: Include in the project the services of an instructor, who shall have received specific training from the manufacturer for the training of other persons regarding the inspection, testing and maintenance of the system provided. The instructor shall train the employees designated by the owner, in the care, adjustment, maintenance, and operation of the fire alarm system.

B. Training sessions shall cover all aspects of system performance, including system architecture, signaling line circuit configurations, sensor and other initiating device types, locations, and addresses, fire alarm control panel function key operation, and other functions as designated by the owner.

C. Required Instruction Time: Provide 4 hours of instruction after final acceptance of the system. The instruction shall be given during regular working hours on such dates and times as are selected by the owner.

D. Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the FACP. The card shall show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory and trouble. The instructions shall be approved by the owner.

E. A Siemens factory branch representative, who has received specific training from the manufacturer, shall conduct all training sessions.

END OF SECTION 28 31 11
SECTION 31 10 00 – SITE CLEARING

1.1 SUMMARY

A. Section Includes:
   1. Protecting existing vegetation to remain.
   2. Removing existing vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping or sealing site utilities.
   7. Temporary erosion- and sedimentation-control measures.

1.2 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

B. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   1. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion and sedimentation control and plant protection measures are in place.

F. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 “Earth Moving.”
   1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion and sedimentation control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site.

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Owner.

3.4 EXISTING UTILITIES
3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
   2. Use only hand methods for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

C. Tree root pruning will be performed by MU Landscape Services. Contractor shall notify Owner's Representative 4 business days in advance.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION
SECTION 31 20 00 – EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation for paving and grading.
   2. Excavation for building foundations, slabs-on-grade, paving, and grading.
   3. Excavation for Site structures.
   4. Site filing and backfilling.
   5. Drainage course for slabs-on-grade.
   6. Consolidation and compaction.
   7. Excavation for trenches for utilities and footings.
   8. Consolidation and compaction of bedding under utilities.
   9. Rough grading.

B. Related Sections:
   2. Section 033000 – Cast-In-Place Concrete.
   3. Section 311000 – Site Clearing.
   4. Section 331100 - Water Utility Distribution Piping
   5. Section 333100 – Sanitary Utility Sewage Piping
   7. Section 334613 – Foundation Drainage.

1.2 DEFINITIONS

A. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials, and bottom of over excavation areas if required by the contract document.

B. Subbase Course: Aggregate layer placed between the subgrade and hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

E. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill, when sufficient approved soil material is not available from excavations.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated, regardless of the character and density of materials, including reuse or disposal of materials removed.
1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Design Professional. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Design Professional. Unauthorized excavation, as well as remedial work directed by Design Professional, shall be without additional compensation.

G. Fill: Suitable materials used to raise existing grades.

H. Finish Grade: The top surface of sod, top surface of topsoil where sod is not indicated or exposed rock surface where indicated on the drawing.

I. Trench Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: For each type of material indicated in Part 2 of this section.

C. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities remaining, rerouted utilities, and new utilities by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

B. Testing Agency: A qualified independent geotechnical engineering testing agency shall classify proposed on-Site and borrow soils to verify that soils comply with specified requirements and to perform specified field and laboratory testing.

C. Pre-excavation Conference:
1. Convene pre-excavation conference under provision of Division 1, one week prior to commencing Work of this Section.
2. Contractor shall be presiding officer at conference.
3. Conference shall be attended by Contractor, Owner’s Representative, testing agency, and earthwork subcontractor.
4. Purpose of conference will be to review contract requirements and discuss schedules, work procedures, acceptable materials specified under this Section, locations where specified materials may be incorporated, and quality control.

1.5 PROJECT CONDITIONS

A. Existing Conditions:
1. Locate existing underground utilities in areas of excavation Work.
   a. Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by Owner’s Representative and then only after acceptable temporary utility services have been provided.
   b. Provide not less than 72 hours notice to Design Professional and Owner’s Representative and receive written authorization to proceed before interrupting any utility.

1.6 MAINTENANCE

A. Where settling is measurable or observable at excavated areas during correction period required by General Conditions, remove surface (pavement, lawn, or other finish), add backfill material, compact as specified in this Section for location of material, and replace surface treatment.
1. Restore appearance, quality, and condition of surface or finish to match adjacent materials.
2. Eliminate evidence of restoration.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. Provide approved borrow soil materials from off-Site when sufficient approved soil materials are not available from excavations, at no increase in Contract Sum or extension of Contract Time.
2. Dispose of any excess materials legally off site at no increase in contract sum or extension of contract time. On site disposal of suitable materials may only be permitted where shown on the drawings.
3. Fill and backfill materials shall be subject to the approval of testing agency and the Owner’s Representative.
4. For approval of fill and backfill materials, notify testing agency and Owner’s Representative at least 5 working days in advance of intention to import material.
   a. Designate proposed borrow area and excavate test pits to permit testing agency to sample as necessary from borrow area for the purpose of making acceptance tests to confirm quality of proposed material.
B. General Fill Materials
   1. Definition: That material used to obtain finish subgrade levels at locations specified under this section.
   2. Acceptable material: Excavated on-Site material or off-Site borrow material which is free from debris, organics, decomposable, and corrodi ble materials, and containing the proper moisture content, liquid limit, and plasticity index to obtain specified compaction requirements.
      a. Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.

C. Low Volume Change Material:
   1. Definition: That material used to obtain the upper 24 inches of finish subgrade beneath granular base in building areas, and material used as trench backfill material in building areas.
   2. Acceptable material:
      a. On-site or Off-Site borrow material which is free from debris, organics, decomposable, and corrodi ble materials with a liquid limit of less than 40 percent and a plasticity index less than 20, or another material acceptable to the testing agency.
         1) Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.
      b. A granular fill containing sufficient fines to exhibit a definite moisture/density relationship.

D. Granular Fill:
   1. Definition: Free-draining granular base used beneath building slabs-on-grade and used as backfill behind foundation and retaining walls.
   2. Acceptable materials: Clean crushed stone or gravel, free of Shale, clay, friable material, and debris, complying with ASTM C33 Size No. 57.

E. Pavement Subbase Course:
   1. Definition: Granular base used beneath concrete pavement and other pavements indicated on Drawings.
   2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.

F. Crushed Limestone Fill Material:
   1. Definition: That material used at trench backfill under pavements, at locations specified under this Section, and at locations indicated on Drawings.
   2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.

G. Bedding Materials: Type 1 aggregate per MoDOT Standard Specification for Highway Construction, Section 1007.

H. Trench Backfill Materials:
   1. Slab on grades: Low volume change materials per this section.
   2. Pavement areas: Low volume change material per this section.
   3. Other areas: General Fill Material or other materials specified under this Section at locations specified or indicated on Drawings.

I. Backfill Material
1. Definition: Material requiring placement and compaction with manual procedures because of restricted spaces or new construction.

2. Acceptable materials: Either General Fill Material, Granular Fill Material, or other materials specified under this Section at locations specified or indicated on Drawings.

J. Suitable Soils: Suitable soils within 36 inches of finished grade in lawn and planter areas shall be cohesive soils in Soil Classification Groups ML, CL, CH or a combination thereof, free of rock or gravel greater than one (1) inch in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter.

K. Unsuitable Material

1. Definition: That excavated material which does not meet the consistency requirements of any other defined materials in this Section, including muck, frozen material, organic material, top soil, rubbish, and rock within the limits defined for General Fill Material.

2. Dispose of unsuitable material off-Site, at no increase in Contract Sum or extension of Contract Time.
   a. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.

1. Verify location and elevations of existing building foundations.
2. Verify location and elevations of existing underground utilities.
3. Verify erosion control systems are in place.
4. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection:

1. Protect trees, shrubs, lawns, other plant growth, and other features indicated on Drawings to remain.
2. Protect bench marks, monuments, existing structures, existing fences, existing roads, existing sidewalks, existing paving, and existing curbs from damage caused by settlement, lateral movement, undermining, washout, and other hazards caused by Work of this Section.
   a. If damaged or displaced, notify Owner’s Representative and correct defects as directed by Owner’s Representative.
3. Protect above and below grade utilities which are to remain.
4. Protect adjacent and downstream properties from pollution, sedimentation, or erosion caused by the work of this Contract.

B. Precautions:

1. Use all means necessary to control dust on and near the Work, and on and near off-Site borrow storage, and spoil areas, if such dust is caused by performance of the Work of this Section, or if resulting from the condition in which Project Site is left by Contractor.
2. Moisten surfaces as required to prevent dust from being a nuisance to the public, neighbors, and concurrent performance of other Work on Project Site.
3. Identify required lines, levels, contours, and datum.
4. Identify above and below grade utilities.
5. Provide and maintain positive surface drainage.

3.3 WATER CONTROL

A. Provide berms or channels to prevent flooding of subgrades.

B. Prevent infiltration of water into excavations from whatever sources as may exist.

C. Prevent ponding of water on finish subgrades.

D. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

E. Prevent flooding of Project Site and surrounding areas.

F. Promptly remove water collection in depressions.
   1. Provide and maintain ample means and devices with which to remove and dispose of water entering excavations.
   2. Ensure dry excavations and preservation of final lines and grades of bottoms of excavations.

3.4 EXCAVATION, GENERAL

A. Use of explosives is not permitted.

B. Excavation above subgrade as defined in paragraph 1.2 of this section is unclassified and includes excavation of any material encountered regardless of its character including rock, soil materials, debris, and other obstructions and shall be included in the base bid.

C. Perform excavation to the lines and grades indicated on Drawings within a tolerance of 0.10 foot.
   1. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.

D. Perform Excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) “Construction Standards for Excavations, 29 CFR Part 1926”.

E. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into excavations.

F. Protect subgrades and foundation soils against freezing temperatures and frost.
   1. Provide protective insulation materials as necessary.

G. When excavating through roots, perform Work by hand cutting roots with sharp axe.
H. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

I. Machine slope banks to comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   1. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
      b. Extend shoring and bracing as excavation progresses
   2. Control surface drainage down slopes.
   3. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.

J. When materials encountered at subgrade are determined to be unacceptable for use by testing agency, remove such material to depths and limits determined by testing agency.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.

K. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency, at no increase in Contract Sum or extension of Contract time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

L. Backfill and compact over-excavations and unauthorized as specified for the area at which it occurs, at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

M. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradation.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

N. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.

O. Hand trim excavations.
   1. Remove loose matter.

P. Excavation for Footings and Foundations:
   1. Do not disturb bottom of excavation.
      a. Excavate by hand to final grade immediately prior to placement of concrete reinforcement.
      b. Trim bottom of excavations to required lines and grades to leave solid base to receive other work.
   2. Drill probe holes at exposed bottom of excavations as directed by testing agency.
3.5 TRENCH EXCAVATIONS

A. Use of explosives is not permitted.

B. Trench excavation is unclassified and includes excavation to required exposed subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.

C. Excavate trenches to gradients, lines, depths, and elevations indicated on Drawings, within a tolerance of 0.10 foot.

D. Perform excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) "Construction Standards for Excavations, 29 CFR Part 1926".

E. Do not perform trench excavation in areas to receive fill until fill operations are complete to an elevation of not less than 24 inches above the top of the proposed pipe or conduit for which the trench is to receive.

F. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into trenches.

G. Protect subgrades against freezing temperatures and frost.

H. Provide protective insulation materials as necessary.

I. When excavating through roots, perform Work by hand cutting roots with a sharp axe.

J. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

K. Excavate trenches to uniform width, sufficiently wide to enable installation of utilities and to allow safe inspection of installed utilities.

L. Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course
   1. Hand excavate for bell of pipe.
   2. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
   3. Comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   4. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in trenches regardless of time period trenches will be open.
      b. Extend shoring and bracing as excavation progresses.
   5. Control surface drainage down slopes.
   6. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.
   7. Hand trim trenches.
      a. Remove loose matter.

M. When subgrade materials are encountered which testing agency determines to be unacceptable for use, remove such material to depths and limits determined by testing agency:
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.
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2. Removal and replacement of unacceptable material will be paid on basis of Unit Prices included in the Contract Documents.

N. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

O. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradations.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

P. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.
   1. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

3.6 SUBGRADE PREPARATION FOR BUILDING SLABS-ON-GRADE

A. General:
   1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
   2. Testing agency shall be present to observe and evaluate subgrades in building areas prior to placement of fill and/or low volume change materials and shall be present during placement and compaction of fill materials in building areas. Undercut as specified herein to develop 18 inch thick low volume change zone below building floor slabs. Subgrades in building areas shall be observed and evaluated by geotechnical engineer prior to fill and/or low volume change placement. Evaluation may include probing by geotechnical engineer and opening of test pits and/or test trenches with contractors assistance to explore areas of suspected unsuitable materials. Subgrades shall also be proof-rolled with loaded tandem axle dump truck in presence of geotechnical engineer and scarified, moisture conditioned and recompacted as specified herein prior to placement of fill and/or low volume change materials.
   3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
   4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by diskling, harrowing, or pulverizing.
   5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
   6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.

8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.

9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.

10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
   a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
   b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   c. Testing agency shall be present during compaction of material.

B. In cut areas below building slabs-on-grade requiring less than 24 inches of fill to obtain finish subgrade elevations, and a lateral distance of 10 feet outside building areas, excavate existing materials to a depth of not less than 24 inches below bottom of floor slab granular fill.

1. Scarify subgrade to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
   a. Moisture condition subgrade to achieve moisture content specified in this Section.
   b. Compact to a minimum of 95% of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill fill areas using low volume change materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material’s maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a
minimum of 95 percent of the material’s maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.

1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.

2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. The upper 24 inches of fill material shall be low volume change material.

6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

C. In areas below building slabs-on-grade requiring 24 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 10 feet outside building areas, scarify subgrade to a depth of 6 inches to result in surface free from ruts, hummocks, and other uneven features which, in the opinion testing agency, would prevent uniform compaction by the equipment proposed for use.

1. Moisture condition subgrade to achieve moisture content specified in this Section.
   a. Compact to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill areas using suitable materials as specified herein placed in loose lifts not exceeding 8 inches. Suitable on-site clay materials may be used below the 24-inch thick low volume change zone.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density at workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. The upper 24 inches of fill material shall be low volume change material.

6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances:
   1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.7 SUBGRADE PREPARATION FOR FOUNDATION FOOTING

A. General:
   1. Excavation for subgrade preparation for foundations is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
   2. Testing agency shall be present during placement and compaction of fill material.
   3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
   4. Moisture condition dry fill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
   5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
   6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
   7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
   8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
   10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
      a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
      b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
      c. Testing agency shall be present during compaction of material.
3.8 SUBGRADE PREPARATION AT PAVEMENTS

A. General:
1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
2. Testing agency shall be present to observe proof-rolling of subgrades in pavement and sidewalk areas prior to placement of fill and shall be present during placement and compaction of fill materials in pavement and sidewalk areas. Testing agency shall also be present to observe proof-rolling of finished subgrades prior to installation of pavement and sidewalk sections.
3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition of dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disk, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from pavement finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
   a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
   b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   c. Testing agency shall be present during compaction of material.

B. In cut areas below pavements requiring less than 12 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, excavate existing material to a depth of not less than 6 inches below bottom of pavement subbase course.
1. Proof-roll subgrade and repair as required in paragraph 3.8.E below, then scarify to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
   a. Moisture condition subgrade to achieve moisture content specified in this Section.
   b. Compact to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill areas using approved materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

4. Maintain subgrade moisture content within specified range until pavements are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

C. In areas below pavements requiring 12 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, proofroll existing subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.
   1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
   2. After proofrolling operations are performed and observed soft areas repaired, place approved material in loose lifts not exceeding 8 inches.
      a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
         1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
         2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
   3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
      a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
         1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. Maintain subgrade moisture content within specified range until pavements are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances
1. Top surface of finish subgrade under paved areas: Plus or minus 1/4 inch from required elevations.

E. Immediately prior to placement of pavement subbase course and pavements, proofroll subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.
1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3.9 GENERAL SITE FILL

A. General:
1. Testing agency shall be present during placement and compaction of fill material.
2. Fill material shall not be placed, spread, or rolled while the material is frozen of thawing, or during unfavorable weather conditions.
3. Moisture condition or dry fill material as required to obtain specified moisture limits.
4. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by dishing, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.

B. Perform grading to the contours and elevations indicated on Drawings:
1. Uniformly grade areas to a smooth surface, free from irregular surface changes.
2. Provide a smooth transition between existing adjacent grades and new grades.

C. Place general fill material in systematic and uniform horizontal lifts not exceeding the following loose-depth-measurements:
1. For fill material to be compacted with heavy compaction equipment: 9 inches.
2. For fill material to be compacted with hand operated tampers: 4 inches.

D. Under sidewalks and ramps compact each lift of material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698
   1. In other areas, compact each lift of material to a minimum of 90 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

E. Bench existing slopes horizontal sections equal in width to equipment used.

F. Where embankments, regardless of height, are placed against hillsides or existing embankments having a slope of steeper than 1 vertical to 5 horizontal, bench or step existing slope in approximately 24 inch rises:
   1. Place fill in lifts not exceeding 9 inches in loose-depth-measurement
   2. Compact material bladed out, bottom area which was cut to form benches, and fill material being placed, to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

G. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
   1. Submit an acceptable agreement with the property owner on whose property the material is placed.

H. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
   2. Top surface of finish subgrade under unpaved surfaces: Plus or minus ½ inch from required elevations.

3.10 INSTALLATION OF GRANULAR FILL

A. Immediately prior to placement floor slab granular base, testing agency will evaluate subgrade to determine whether moisture content is within specified range, and whether subgrade has been disturbed.
   1. In areas where testing agency determines subgrade is not within specified moisture content range, remove non-complying areas and replace and recompact to required density, within specified moisture content range, as directed by testing agency.
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3.11 INSTALLATION OF PAVEMENT SUBBASE COURSE

A. Place pavement subbase course in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill for pavement and sidewalk subbase course to a minimum of 95 percent of the material’s maximum standard proctor dry density in accordance with ASTM D698.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and “wacker” compaction equipment.
   3. Qualitative tests shall be taken after the compaction of each layer of fill by testing agency.

B. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

3.12 BEDDING

A. Place and compact bedding course on trench bottoms and where indicated on Drawings.
   1. Install materials in continuous layers not exceeding 6 inches compacted depth.

B. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Install bedding to a depth of 6 inches below bottom of pipe bell or conduit, to an elevation of 6 inches above pipe or conduit.
D. Compact bedding materials by slicing with a shovel and compacting with vibratory plates and "wacker" compaction equipment.

E. Support pipe and conduit during placement and compaction of bedding fill.

3.13 INSTALLATION OF BACKFILL

A. Backfill excavations promptly, but not before completion of the following:
   1. Surveying location of underground utilities for Record Documents
   2. Testing, inspecting, and approval of underground utilities
   3. Removal of concrete forms
   4. Removal of lumber, rock, paper, and other debris from areas to be backfilled
   5. Removal of temporary shoring, bracing, and sheeting

B. Backfill areas to contours and elevations indicated on Drawings, using unfrozen backfill material
   1. Do not backfill over porous, wet, frozen, thawing, or spongy surfaces
   2. Do not backfill during unfavorable weather conditions
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits
      a. Material which is too wet to allow proper compaction, as determined by testing agency
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness
   5. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency
   6. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously laced backfill areas is as specified
   7. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   8. Compaction in lawn and planter areas is 85% maximum.

C. Backfilling of curbs, slabs-on-grade, and other structures whose foundation is unprotected from water shall be accomplished as soon as forms are removed, to eliminate possibility of softening of subbase below structure

D. Backfill foundation walls with granular material, not less than 24 inches in width, to an elevation of 2 feet below finish grade.
   1. Backfill simultaneously on each side of unsupported foundation walls.
   2. Backfill upper 2 feet using General Fill Material.

E. Backfill trenches to contours and elevations indicated on Drawings, using unfrozen backfill material.
   1. Do not backfill over porous, wet, frozen, or spongy surfaces.
   2. Do not backfill during unfavorable weather conditions.
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness.
      a. Employ a placement method of backfill operations which does not disturb or damage utilities in trenches.
Backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings with concrete.
   1. Place concrete to elevation equal to bottom of footings.

Compaction of General Backfill
   1. Maintain optimum moisture content of backfill materials to attain required compaction density.
   2. General Fill Materials used for backfill shall be placed in lifts not exceeding 9 inches in loose-depth-measure and compacted as specified for General Site Fill.
   3. Granular Fill Materials used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted as specified for Granular Fill.
   4. Field density tests shall be taken after the compaction of each layer of backfill by testing agency.
      a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

Compaction of Trench Backfill
   1. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency.
   2. Maintain optimum moisture content of backfill materials to attain required compaction density.
   3. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill area is as specified.
   4. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   5. General Fill Material used for backfill shall be placed in lifts not exceeding 4 inches in loose-depth-measure with each lift compacted as specified in this section.
   6. MoDOT Standard Specification for Highway Construction Type 5 aggregate used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted to a minimum of 97 percent of the material’s maximum Standard Proctor dry density with a moisture content near optimum in accordance with ASTM D698.
   7. Field density tests shall be taken after the completion of each layer of backfill by testing agency.
      a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

Slope grade away from building not less than 12 inches in 10 foot for a distance of not less than 6 feet outside of building lines.
   1. Make grade changes gradual.
   2. Blend slopes into level areas.
   3. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
   4. Submit an acceptable agreement with the property owner on whose property the material is placed.

Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations
   2. Top surface of finish subgrade under unpaved areas: Plus or minus ½ inch from required elevations
3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 6938, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.15 PROTECTION

A. Protect newly graded areas from freezing and erosion.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.

D. Testing agency shall be present during compaction of material.

END OF SECTION
SECTION 31 63 29 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Dry-installed drilled piers.

1.3 UNIT PRICES

A. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments are made on net variation of total quantities, based on design dimensions for shafts and bells.

1. Base bids on indicated number of drilled piers and, for each pier, the design length from top elevation to bottom of shaft, and the diameter of shaft.
2. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, testing and inspecting, and other items for complete drilled-pier installation.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to drilled piers including, but not limited to, the following:

   a. Review geotechnical report.
   b. Discuss existing utilities and subsurface conditions.
   c. Review coordination with temporary controls and protections.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete mixture. Submit alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

   1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Shop Drawings: For concrete reinforcement, detailing fabricating, bending, supporting, and placing.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and land surveyor.

B. Welding certificates.

C. Material Certificates: From manufacturer, for the following:

   1. Cementitious materials.
   2. Admixtures.
   3. Steel reinforcement and accessories.

D. Material Test Reports: For each material below, by a qualified testing agency:

   1. Aggregates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Record drawings.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
1.9 FIELD CONDITIONS

A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.

1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.

B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Do not proceed with interruption of utility without Owner's written permission.

C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
2. The geotechnical report is included elsewhere in the Project Manual.

D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

1. Record and maintain information pertinent to each drilled pier and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Drilled-Pier Standard: Comply with ACI 336.1 except as modified in this Section.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150/C 150M, Type I/II. Supplement with the following:
   a. Fly Ash: ASTM C 618, Class C or Class F.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregate: ASTM C 33/C 33M, graded, not larger than 3/4 of the minimum clear spacing between individual reinforcing bars. Provide aggregate from a single source.

1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.


D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.

E. Sand-Cement Grout: Portland cement, ASTM C 150/C 150M, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi, of consistency required for application.

2.4 STEEL CASINGS

A. Liners: Comply with ACI 336.1.

2.5 CONCRETE MIXTURES

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

D. Proportion normal-weight concrete mixture as follows:

2. Maximum Water-Cementitious Materials Ratio: 0.45.
3. Minimum Slump: Capable of maintaining the following slump until completion of placement:
   a. 4 inches for dry, uncased, or permanent-cased drilling method.
   b. 6 inches for temporary-casing drilling method.
4. Air Content: Do not air entrain concrete.

2.6 REINFORCEMENT FABRICATION
   A. Fabricate steel reinforcement according to CRSI’s "Manual of Standard Practice."

2.7 CONCRETE MIXING
   A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.2 EXCAVATION
   A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
   1. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time are authorized for removal of obstructions.
   B. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
   C. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
2. Remove water from excavated shafts before concreting.

D. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.

1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
2. Payment for additional authorized excavation is according to Contract provisions for changes in the Work.

E. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.

1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete, or leave temporary casings in place.

F. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.

1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

3.3 STEEL REINFORCEMENT INSTALLATION

A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.

C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.

D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.

E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.

F. Protect exposed ends of extended reinforcement or anchor bolts from mechanical damage and exposure to weather.
3.4 CONCRETE PLACEMENT

A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified testing agency.

1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.

B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.

1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
2. Vibrate top 60 inches of concrete.

C. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch head of concrete above bottom of casing.

1. Vibrate top 60 inches of concrete after withdrawal of temporary casing.

D. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.

E. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.

1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.

F. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than 90 deg F.

1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Drilled piers.
2. Excavation.
3. Concrete.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.

1. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities are determined by testing and inspecting agency. Final evaluations and approval of data are determined by Architect.
   a. Bearing Stratum Tests: Testing agency takes undisturbed hardpan core samples from drilled-pier bottoms; tests each sample for compression, moisture content, and density; and reports results and evaluations.

D. Concrete Tests and Inspections: ASTM C 172/C 172M except modified for slump to comply with ASTM C 94/C 94M.

1. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
2. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and 80 deg F and above, and one test for each set of compressive-strength specimens.
3. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
4. Compressive-Strength Tests: ASTM C 39/C 39M; one set for each drilled pier but not more than one set for each truck load. Test one specimen at seven days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
5. If frequency of testing provides fewer than five strength tests for a given class of concrete, conduct tests from at least five randomly selected batches or from each batch if fewer than five are used.
6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
7. Strength of each concrete mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.
9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but not be used as sole basis for approval or rejection of concrete.

10. Additional Tests: Testing and inspecting agency to make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.

   a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.

11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.

12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

E. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports for each drilled pier as follows:

1. Actual top and bottom elevations.
2. Actual drilled-pier diameter at top, bottom.
3. Description of soil materials.
4. Description, location, and dimensions of obstructions.
5. Final top centerline location and deviations from requirements.
6. Variation of shaft from plumb.
7. Shaft excavating method.
8. Design and tested bearing capacity of bottom.
9. Levelness of bottom and adequacy of cleanout.
10. Ground-water conditions and water-infiltration rate, depth, and pumping.
11. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
12. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
13. Date and time of starting and completing excavation.
15. Condition of reinforcing steel and splices.
17. Concrete placing method, including elevation of consolidation and delays.
20. Concrete volume.
21. Concrete testing results.
22. Remarks, unusual conditions encountered, and deviations from requirements.
3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 63 29
SECTION 32 92 19 – SEEDING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section covers furnishing and sowing seed, compacting, mulching, and establishing turf in accordance with this specification at the locations shown on the drawings.

B. Furnish all labor, tools, equipment, material, and perform all operations necessary and incidental to proper execution and completion of all work in accordance with the drawings and specifications.

C. Limits of seeding are shown on the drawings.

PART 2 - PRODUCTS

2.1 SEED

A. All seed shall be furnished in sealed containers. Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be acceptable. The seed mixture shall be as follows: Submit all seed certificates to the Owner's Representative.

2.2 SEED MIXTURES

A. Hybrid Fescue Mix “Rebel II” or “Falcon”
   1. Hybrid Fine Fescue:
      a. Minimum % Pure Live Seed: 95%
      b. % Germ.: 85%
      c. Rate of App. Per 1000 SF: 9 lbs. For soccer field, 7 lbs for all other areas.
   2. Kentucky Bluegrass
      a. Minimum % Pure Live Seed: 80%
      b. % Germ.: 70%
      c. Rate of App. Per 1000 SF: 1 lb.

2.3 MULCH

A. Straw mulch shall be the thrashed plant residue of oats, wheat, barley, or rye from which grain has been removed or optional wood cellulose fiber applied by the hydro-mulching method. The straw shall be free of prohibitive weed seeds as stated in the Missouri Seed Law, and shall be relatively free of all other obnoxious and undesirable seeds.

B. Commercial grade wood cellulose fiber. Nominal moisture content not exceeding 12 percent.
2.4 SOIL FOR REPAIRS

A. Soil for filling areas to be repaired shall be topsoil free of large stones, clods, roots, stumps, or other materials that would interfere with subsequent seeding, compacting, or establishment.

PART 3 - EXECUTION

3.1 GENERAL

A. Areas to be seeded are all areas disturbed by construction not covered by pavement, structures or landscape.

B. Soil preparation, applying fertilizer, finish grading, removal of weed growth, and all other operations necessary to prepare the seed bed prior to sowing seed is covered in section FINE GRADING AND FERTILIZING. THE SEED BED MUST BE IN A LOOSE, FINE, WELL-AGGREGATED CONDITION AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO SEEDING.

C. Skipped areas wider than the distance between drills, in case of drilling operations or areas averaging more than four (4) inches in width in the case of broadcasting operations shall be reseeded. Drill sowing is the preferred method.

3.2 SOWING SEED

A. All sowing of seed shall be completed between the dates of March 15 and May 30 for spring seeding; and August 15 and October 1 for fall seeding. Sowing delayed beyond the specified dates, and due to circumstances beyond the contractor’s control, may be continued upon written approval.

B. The sowing may be stopped when satisfactory results are not likely to be obtained due to drought conditions, excessive moisture, high wind or other unfavorable conditions. Sowing of seed shall be resumed only when conditions are again favorable or when alternative or corrective measures and approved procedures have been adopted.

C. Broadcast Sowing: Seed shall be broadcast by approved sowing equipment where drill sowing is not practical, at a rate which will provide not less than the minimum quantity of seed stated in these specifications. The seed shall be uniformly distributed over the designated areas. Broadcast sowing shall not be done when the wind exceeds a velocity of five (5) miles per hour. The seed shall be placed ¼” to ⅜” in the soil by means of a harrow or cultipacker.

3.3 HYDROSEEDING

A. Mix specified seed, fertilizer and wood cellulose fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic.

1. Use of 45 pounds of wood cellulose fiber mulch per 1,000 square feet of area.
3.4 COMPACTING

A. Not applicable if hydroseeding.

B. Immediately after the sowing operations have been completed, the entire area shall be compacted by means of a cultipacker, roller or other approved equipment, in order to reduce air pockets to a minimum. When a cultipacker, or other approved equipment that leaves a roughened surface is used, the final rolling shall be along the contour and at right angles to the prevailing winds to reduce dust. If the mulching operation can be accomplished the same working day the area is seeded, compacting the seed and anchoring the mulch may be done at the same time.

3.5 MULCHING

A. Not applicable if hydroseeding.

B. Straw mulch shall be spread uniformly in a continuous blanket, using not less than 2,000 lb. Per acre or one (1) bale per 1,000 square feet, approximately 4 to 5 straws deep and having soil show through mulch. Mulching shall start at the windward side of relatively flat areas, or at the upper part of a steep slope, and shall continue until the area is completely covered.

C. Immediately following spreading of the straw, the material shall be anchored to the soil by a V-type wheel land packer, a disc harrow set to cut only slightly, or other suitable equipment which will secure the straw firmly in the ground to form a soft binding mulch and prevent loss or bunching by the wind.

3.6 MAINTENANCE

A. Begin maintenance of new turf areas immediately after each area is planted and continue until accepted as specified.

B. Maintain turf by watering, fertilizing, weeding, rolling, regrading and replanting as required to establish a smooth, acceptable turf, free of eroded or bare areas.

C. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

D. Replant bare areas with same materials as originally specified.

E. Watering: Watering of seeded areas for germination and establishment is not required. However, the Contractor shall unconditionally guarantee an acceptable stand of grass in all seeded areas. If the Contractor elects to water, provide and maintain temporary piping, hoses,
watering equipment, and vehicles as required to convey water and to keep turf areas uniformly moist as required for proper growth and acceptability.

F. Program watering schedule to prevent puddling, water erosion and displacement of seed or mulch.

3.7 MAINTENANCE FERTILIZING

A. 6 to 8 weeks after the original seeding and prior to the first mowing, the Contractor shall apply maintenance fertilizer. Analysis shall be as recommended by the soil test.

3.8 REPAIRS OF SEEDED AREAS

A. When the surface has become gullied or otherwise damaged during the period of establishing turf, the affected area shall be repaired to reestablish the grade and the condition of the soil, and shall be reseeded at the original seed rate. Fill material shall be placed and compacted in six (6) inch lifts. Reseeding shall be done in a manner that will cause a minimum of disturbance to the existing stand of grass.

3.9 ACCEPTANCE

A. When work is completed and seeded areas are in an acceptable condition as specified herein, Owner will, upon request, make an inspection to verify acceptability.
   1. Immediately prior to an inspection, Contractor shall mow the area to be inspected for acceptance. The Owner will do mowing for maintenance.

B. Replant rejected work and continue specified maintenance until reinspected by Owner and found acceptable.

C. Seeded areas will be acceptable provided a uniform stand of specified grass is established that is reasonably free of weeds, bare spots, and surface irregularities, as determined by the Owner and is at least 2 inches tall.

3.10 CLEANUP

A. Promptly remove soil and debris created by seeding work from paved areas and overspreads of hydrosedding mulch from pavement, fences and structures. During the progress of the work, clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas.

END OF SECTION
SECTION 33 11 00 – WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. All water utility distribution piping shall be in accordance with the attached City of Columbia Specifications for Water Main Construction, revised October 1, 2015.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION
STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Storm sewage piping.
   2. Junction boxes.
   3. Inlets.
   4. Yard drains.
   5. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer’s specifications and technical data on the following:
   1. Piping.
   2. Fittings.
   3. Yard Drains.

C. Shop Drawings: Indicate dimensions, description of materials, general construction, specific modifications, component connections, and installation procedures, plus the following specific requirements:

D. Include junction boxes, inlets, frames, covers, and grates.

E. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.
1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.

B. Storage and Protection: Comply with manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforced Concrete Pipe: ASTM C76, Class III.
   1. Fittings: Same strength of adjoining pipe.
   2. Joints:
      a. Gaskets: Contractor has option of the following:
         1) ASTM C443, flat gaskets cemented to pipe tongue or spigot.
         2) ASTM C443 O-ring gaskets.
         3) ASTM C443 roll-on gaskets.


C. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S.

D. Concrete:
   1. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

2.2 COMPONENTS

A. Junction Boxes: ASTM C858, precast reinforced concrete.
   1. Base section:
      a. Floor slab: 8 inch thick.
      b. Walls: 6 inch thick.
      c. Base riser section: 6 inch thick.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on Drawings.
      a. Top of cone to match grade rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: ASTM C443, rubber.
   6. Steps: Cast iron steps, case into base, riser and top sections at 16 inch intervals.
   7. Frame and cover: ASTM A48, Class 35B gray iron.
      a. Frame size: 24 inch diameter, by 9 inch riser with 4 inch width flange.
      b. Cover: 26 inch diameter, indented top design, with lettering “STORM SEWER” cast into cover.
STORM UTILITY DRAINAGE PIPING

2.3 ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape, 6 inches wide by 4 mils thick.
   1. Imprint warning tape with "CAUTION – SEWER SERVICE LINE BURIED BELOW" in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Backfill Materials: As specified under Section 312000.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Trenching: Comply with requirements of Section 312000.
STORM UTILITY DRAINAGE PIPING

1. Grade trench bottom to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
   a. Backfill with bedding material.
3. Shape bottom of trench to fit design of pipe.
   a. Fill unevenness with tamped bedding material.
   b. Dig bell holes at each pipe joint to assure continuous bearing of pipe.

B. Install bedding material at trench bottom in accordance with Section 312000.
   1. Install bedding materials in continuous layers not exceeding 6 inches in compacted depth, to total depths indicated on Drawings.
   2. Compact bedding materials as specified under Section 312000.

C. Pipe Installation: Comply with pipe manufacturers instructions.
   1. Install pipe beginning at low point of system, true to grades and alignment indicated on Drawings and unbroken continuity of invert.
   2. Install concrete pipe in accordance with ACPA Concrete Piping Installation Manual.
   3. Install polyethylene corrugated pipe in accordance with ASTM D2321.
      a. Install fittings in accordance with manufacturer’s instructions.
   4. Install PVC pipe in accordance with ASTM D2855 and ASTM F402.
   5. Place bell ends or groove ends of piping facing upstream.
   6. Install gaskets in accordance with manufacturer’s instructions.
   7. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
   8. Clean interior of piping as Work progresses.
   9. Maintain swab or drag line and pull past each joint as it is completed.
   10. Install plugs in ends of incomplete piping at end of each day.

D. Install junction boxes complete with accessories indicated on Drawings.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame flush with adjacent landscaped surfaces, unless otherwise indicated on Drawings.

E. Install inlets complete with accessories indicated on Drawings.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame flush with adjacent landscaped surfaces.

F. Install cleanouts and extension from storm drainage pipe to cleanout at grade at locations indicated on Drawings.
   1. Set cleanout frame and cover in concrete pad, 18 inches by 18 inches by 12 inches deep except at where location is in concrete paving.
   2. Set top of cleanout 1 inch above surrounding earth grade.
   3. Set top of cleanout flush with surrounding pavement.

G. Tap Connections:
   1. Make connections to existing storm sewer and underground structures to comply with requirements of this Section, as indicated on Drawings.
H. Install underground warning tape continuous buried 6 inches below finish grade, above pipe line.
   1. Coordinate with Section 312000.

I. Backfilling: Comply with requirements of Section 312000.

3.3 PROTECTION

A. Protect installed sewage system from damage of displacement until backfilling operation is complete.

END OF SECTION
SECTION 33 46 13 – FOUNDATION DRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Building perimeter drainage system.
   2. Retaining wall drainage system.
   3. Under slab-on-fill drainage system.
   4. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.
   2. Section 334100 - Storm Utility Drainage Piping.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

1.3 PRODUCT DATA

A. Manufacturer’s specifications and technical data including the following:
   1. Pipe drainage products and accessories.

B. Samples:
   1. Submit samples of the following:

C. Contract Closeout Submittals: Submit in accordance with Division 1.

D. Project Record Documents.
   1. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.
1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.

B. Storage and Protection: Comply with manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Polyvinyl Chloride (PVC) Pipe and Fittings: ASTM D3034, SDR 35, with socket and spigot ends.
   1. Size: 4 inch diameter.
   2. Provide unperforated pipe through sleeved walls.
   3. Provide unperforated pipe under paved areas.
   4. Provide perforated pipe at subdrainage and underdrain systems.
      a. Perforations: Standard pattern per ASTM D2729:
         1) Nominal Pipe Size: 4” - 6”
         2) Hole Size: 1/2”
         3) Hole Spacing: 5” ± 1/4”
         4) Hole Rows: 2 @ 120° (±5°)

B. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S. All joints shall meet the requirements of a soiltight joint unless otherwise specified.
   1. Perforation: Class II perforation per AASHTO M252 and M294.

C. Fittings: As required for installation of drainage system.

D. Filter Aggregate and Bedding Materials: Granular Fill as specified under Section 312000.

E. Drainage Panels: Prefabricated geocomposite, 36 to 60 inches (915 to 1525 mm) wide with drainage core faced with geotextile filter fabric.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Comparable product by one of the following:
      a. American Wick Drain.
      b. Cosella-Dorken Products, Inc.
      c. Eljen Corporation.
      d. Greenstreak.
      e. JDR Enterprises, Inc.
      f. Midwest Diversified Technologies Incorporated.
      g. TenCate Geosynthetics.
      h. Trace-LINQ Inc.
   3. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
a. Minimum Compressive Strength: 10,000 lbf/sq. ft. (479 kPa) when tested according to ASTM D1621.

b. Minimum In-Plane Flow Rate: 2.8 gpm/ft. (35 L/min. per m) of unit width at hydraulic gradient of 1.0 and compressive stress of 25 psig (172 kPa) when tested according to ASTM D4716.

4. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M288:
   a. Survivability: Class 1.
   b. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum.
   c. Permittivity: 0.5 per second, minimum.

5. Film Backing: Polymeric film bonded to drainage core surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preparation
   1. Grade bottom of excavations to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with clean sand or pea gravel.
   3. Shape bottom of excavation to fit design of pipe.
      a. Fill unevenness with tamped sand backfill.
   4. Remove large stones or other hard matter which could damage drainage pipe or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Comply with manufacturer’s instructions.

B. Install pipe beginning at low point of system, true to grades and alignment indicated, with maximum variation from true slope of 1/8 inch in 10 feet.
   1. Install PVC pipe in accordance with ASTM D2855 and ASTM F402.
   2. Cap upper ends of pipe.

C. Install filter fabric over subgrade in area to receive perforated pipe.
   1. Place 2 inch deep by not less than 12 inch wide bedding aggregate over filter fabric.

D. Install pipe over bedding aggregate with perforations facing down.
   1. Mechanically join pipe ends.
E. Install drainage panel over waterproofing in accordance with manufacturer’s instructions.
   1. Overlay drainage panel filter fabric in the direction of water flow at panel joints.
   3. Coordinate installation with Division 7.

F. Install filter aggregate at sides and top of pipe in 4 inch lifts.
   1. Do not displace or damage pipe when placing filter aggregate.
   2. Provide top cover of filter aggregate of not less than 24 inches of depth, and as indicated on Drawings.
   3. Level top of aggregate cover.

G. Wrap filter fabric over aggregate cover prior to backfilling.

H. Coordinate final backfilling and compaction operations with Sections 312000.
   1. Do not allow backfilling operations to commence without observation of completed system by Engineer.
   2. Do not allow drainage pipe to be displaced during backfilling and compaction operations.

I. Connect drainage pipe to storm drainage system using unperforated pipe or through installed sleeves.

3.4 FIELD QUALITY CONTROL

A. Provide in accordance with Division 1.

B. Inspections: Allow Engineer to observe installed system prior to installation of filter aggregate cover.

C. Tests: Upon completion of installation, test drainage pipe for free flow of water.

END OF SECTION